2000

Federal Aviation Administration
National Aviation Research Plan

U.S. Department of Transportation
Federal Aviation Administration

February 2000

Report of the Federal Aviation Administration
to the United States Congress
pursuant to 49 United States Code 44501(c)

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1.0 OVERVIEW

1.1 Research and Development Responsibilities and Objectives

Everyone takes a keen interest in what the FAA is doing—the Congress, industry, the media, the public ... that's because aviation touches our lives in so many ways. People rightly demand the safest, most reliable system possible. They expect the planes to be safe, their flights to be on time, and their luggage to be on the carrousel. And they expect peak performance around the clock, day after day, year in, year out.

— Jane F. Garvey, FAA Administrator, May 21, 1999

The United States President, Congress, and the American public hold the Federal Aviation Administration responsible for providing a safe, secure, and efficient National Airspace System (NAS). Furthermore, they expect FAA actions and regulations to be effective in improving aviation safety and security while still mitigating the impacts of aircraft noise and emissions upon the environment. Better research and the implementation of effective new solutions increasingly hold the key to meeting the rising expectations of the American people and their Government.

The significance of the FAA's research and development (R&D) will grow in proportion with the demands placed upon it. The FAA's R&D program finds and prepares to field technologies, systems, designs, and procedures that directly support the agency's principal operational and regulatory responsibilities: air traffic services, certification of aircraft and aviation personnel, operation and certification of airports, civil aviation security, and environmental standards for civil aviation.

Safety remains the agency's top priority. While the FAA, NASA, and other R&D sources have introduced many new technologies and procedures over the past 20 years—and the accident rate has dropped dramatically as a result—expectations are constantly being raised. The R&D program supports essential agency initiatives to reduce fatal accidents by 80 percent by the year 2007. Without a major infusion of new technologies and procedures, it will be extremely difficult for the FAA and the aviation community to meet this goal.

To support the agency's principal operational and regulatory responsibilities, the FAA's R&D program is functionally divided into seven areas: Air Traffic Services, Airport Safety Technology, Aircraft Safety, System Security, Human Factors, Environment and Energy, and an overall planning and coordinating function titled R,E&D Program Direction. Each of these areas will be described briefly in Section 1.6 of this Overview and reported on in detail in their respective sections of this Plan.

1.2 Civil Aviation and the Nation

Economic Importance

Technical and procedural insights gained from FAA R&D affect the largest export sector of our national economy. A viable FAA R&D program is critical to ensure the continued safety and efficiency of the air transportation system and, as a result, U.S. technical and economic leadership in international aviation. 1998 estimates (see Table 1) concentrating on just the U.S. scheduled airlines and their associated spending account for 3.2 percent of our Gross Domestic Product (GDP). U.S. aviation industries hope to deliver over 14,000 transport aircraft valued at $1 trillion over the next 20 years. Figures developed in 1993 and not yet updated, estimated that the total effect of aviation and related industries contributed almost 6 percent to the GDP and provided over 8 million jobs.

Table 1: Airline Spending (Air Transport Association of America)

Airline Spending *For the 12 months ending December 31, 1998*	
Labor Compensation	(in billions) $ 33.1
Materials Purchased	16.5
Services Purchased	21.5
Capital Expenses	17.2
Other Expenses	20.8
TOTAL DIRECT SPENDING	109.1
TOTAL INDIRECT SPENDING	109.1
TOTAL INDUCED SPENDING	54.6
TOTAL GDP CONTRIBUTION	$272.8
AIRLINE SPENDING AS A% OF GDP	3.2%

Aviation-related research and development is accelerating in other nations and improving their commercial aviation products. Increased foreign competition is showing signs of eroding our international position. Effective R&D is a major factor determining the leadership and market share in vibrant industries such as aviation.

Forecasted Needs

The FAA forecasts that domestic air carrier revenue passenger miles will increase 3.8 percent annually between fiscal years 2000–2008. (See Figure 1-1) Projections assume that domestic passenger yields will increase 1.7 percent annually over the forecast period, and international air carrier revenue passenger miles and enplanements will increase 5.3 percent annually. The numbers of passengers carried on commercial aircraft will soon nearly double, reaching one billion by 2015. This projected growth will increase the strain on the air transportation system's capacity, safety, and security.

Recent armed conflicts have shown that, without a sense of security, air travelers will change their mode of transportation or dramatically decrease their travel. While statistics may not justify the flying public's fears and concerns, these perceptions become a reality that must be addressed. The FAA R&D program is focusing on developing methods and innovations that will ensure the safety that the public demands.

1.3 Need for Modernization

In the course of the 1990s, many calls have come to the agency to do business differently—some of them from outside the DOT/FAA ranks, and some from within. All of the advocates of change described in this section have contributed to a growing spirit of modernization both in systems and in the operating "culture" of the agency.

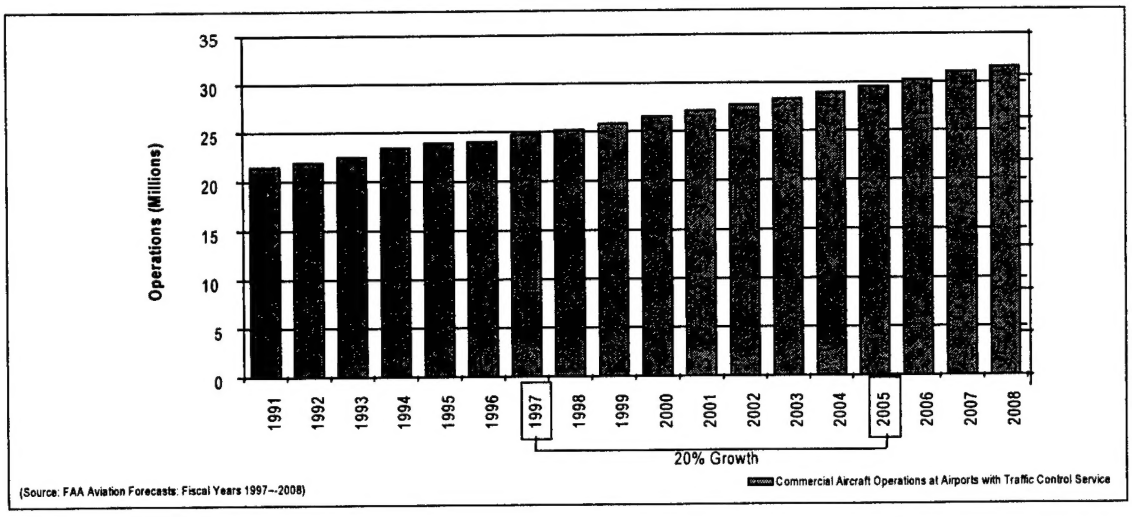

Figure 1-1. Commercial Aircraft Operation

1.3.1 External Motivators

Government Performance and Results Act of 1993

No recent legislation has posed a greater challenge to traditional business practices throughout the Federal Government than the Government Performance and Results Act of 1993 (GPRA). The FAA R&D program's first GPRA challenge was to learn how to apply the terms to its own operating environment. Figure 1-2 illustrates key GPRA concepts as applied to the R&D culture.

The FAA now emphasizes GPRA concepts throughout the National Aviation Research Plan. As shown in the diagram, the R&D program partners with its stakeholders responds to various inputs and provides its customers with outputs that will bring about favorable outcomes. In other words, the R&D program partners with members of academia, industry, unions, and other government agencies; responds to the demands placed upon it; and provides industry, the public, and the aviation community with products, such as regulations or prototype systems, that will solve problems and increase capabilities.

The primary challenge in the FAA R&D process is to understand how emerging technologies should be packaged into outputs that will lead to desirable outcomes. The secondary challenge is to understand and to quantify the impact and influence of emerging technologies upon existing and future conditions. The initiatives described in Section 1.4 show why DOT and its components

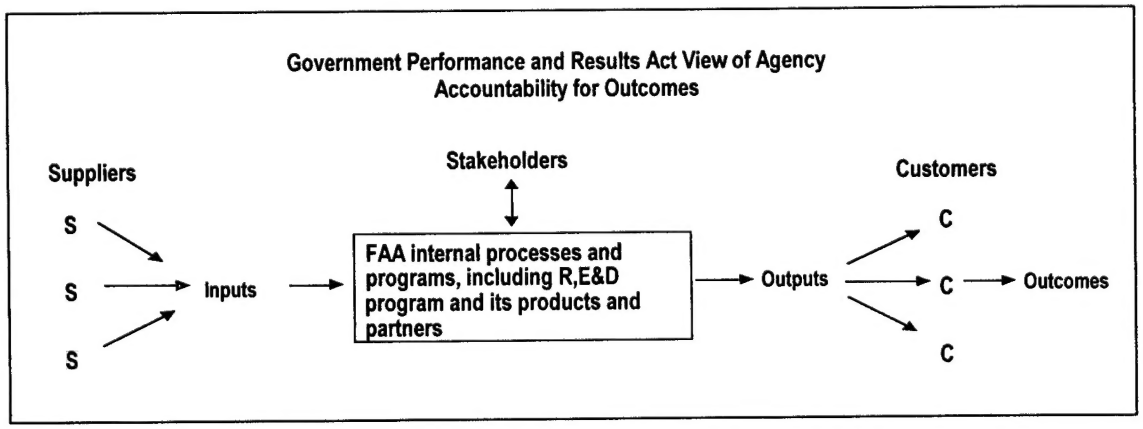

Figure 1-2. FAA R&D Program and GPRA terminology

have earned a good reputation for adhering to GPRA guidelines and principles.

White House Commission on Aviation Safety and Security

In August 1996, White House Executive Order 13015 established the Commission on Aviation Safety and Security. Chaired by Vice President Al Gore, the commission is referred to informally in the aviation community as the "Gore Commission." Included in its initial mandate was the requirement to review the current status of NAS modernization efforts and recommend changes if required.

After presenting its key recommendations on the funding of new aviation safety and security initiatives, the group's final report concluded: "...the commission believes that the safety and efficiency improvements that will come with a modernized system should not be delayed and recommends that the program be accelerated to achieve full operational capability by 2005."

This recommendation represents a significant challenge and opportunity for R&D, one that can be met only with a renewed sense of dedication and expanded partnerships with industry and academia.

President's Commission on Critical Infrastructure Protection

The President's Commission on Critical Infrastructure Protection was the first national forum to address the vulnerabilities created in the new information age. Established in July 1996 by Executive Order 13010, the commission was chaired by aerospace industry leader Robert "Tom" Marsh. Its charter was to provide advice and assistance to the President in finding current and viable means to protect critical infrastructures, including aviation, from physical and cyber threats.

An advisory committee of industry leaders supported the main body, and a steering committee of cabinet-level officials reviewed the final report, *Critical Foundations*, before sending it to the President in October 1997.

National Civil Aviation Review Commission

In its final report (December 1997), the National Civil Aviation Review Commission (NCARC) recommended broad and sweeping changes in the ways the FAA is managed, sets its priorities, assesses and achieves performance outcomes, and is financed. The Commission made five broad recommendations:

- FAA's funding and financing system receive a Federal Budget treatment ensuring that revenues from aviation users and spending on aviation services be directly linked and shielded from discretionary budget caps.
- Air traffic control services be placed in a performance-based organization managed by a chief operating officer and overseen by a board of public interest directors.
- FAA adopt a cost-based revenue stream to support its air traffic system activities, including capital investments.
- FAA operating costs be better managed and controlled and investments in air traffic control modernization be increased.
- The Airport Improvement Program be funded at a minimum of $2 billion annually over the next five years.

1.3.2 DOT/FAA-Internal Motivators

DOT Flagship Initiatives

One hundred and eighty senior leaders from all components of DOT met for two days in February of 1999 as the department's first-ever expanded Senior Leadership Team. Their charter was to identify ways to improve overall cooperation among the various DOT components and ensure consensus on crosscutting issues. The team agreed that the two years ushering in the new millennium posed public credibility issues beyond the transportation establishment's normal day-to-day activities

The results of their discussions form a two-year strategic agenda with its roots in the department's Strategic and Performance Plans—documents judged to be highly responsive to GPRA requirements and intent. The initiatives selected for inclusion in the agenda answered the question: By what criteria will the public judge the overall performance of DOT in the year 2000? Items that made the list became DOT "Flagship Initiatives."

The Flagship Initiatives are almost all "intermodal," that is, they involve more than one major component of the department. They cluster

around five DOT strategic goals: safety, mobility, economic growth and trade, human and natural environment, and national security. In some cases, the Initiatives involving the FAA refer directly to R&D issues, but performance of successful research and development underlies nearly all.

The following DOT Flagship Initiatives directly involve the FAA:

- *Safety*
  - Fatigue/Alertness and other Human Factors Issues
  - Hazardous Materials handling/Incidents
  - Safer Skies: A Focused Agenda
- *Mobility*
  - Free Flight Phase 1
- *GPS*
- *Economic Growth and Trade*
  - Domestic Aviation (various concerns)
  - Free Flight Phase 1
  - Global Transportation
- *Natural Environment*
  - Aircraft Noise Standards
- *National Security*
  - Reduce Flow of Illegal Drugs/Illegal Aliens
  - Implement Gore Commission Recommendations
  - 1999 Federal Radionavigation Plan
  - Peacetime Engagement/Nation-Building Operations
  - Partnership with DOD and other Defense-Related Agencies

FAA Administrator

It will be clear in the descriptions of many initiatives described in Section 1.4 that the Office of the FAA Administrator is firmly behind NAS modernization and its related activities. The following remarks from the Administrator's speeches further illustrate this commitment:

> "The Gore Commission gave the FAA a mandate — modernize the air traffic control system. .... It cannot be business as usual. Let me rephrase that — it will not be business as usual. Our job is too important."
>
> — March 12, 1998
>
> "Success with Free Flight Phase 1 will show that we can do what we say we will do. That we can do what needs to be done — on time and on budget."
>
> — September 30, 1998
>
> "What drives us to work so hard and so well together is that we all know that Safer Skies is absolutely the right approach. This data-driven, prioritized, and measured approach is the best way to enhance aviation safety. Safer Skies is the right thing to do."
>
> — April 15, 1999

R,E&D Advisory Committee

The FAA's R,E&D Advisory Committee (REDAC), established in 1989, advises the Administrator on research and development issues and provides a liaison between the FAA R&D program and those of industry, academia, and other government agencies. The committee considers aviation research needs in air traffic services, airport technology, aircraft safety, aviation security, human factors, and the environment.

Up to thirty members may serve on the Committee. They serve two-year terms and represent corporations, universities, associations, consumers and other government agencies. The FAA's Director of Aviation Research, serves as the executive director of the committee. The REDAC meets two times during the year: in April and in September.

NASA's Aero-Space Technology Advisory Committee and FAA's R,E&D Advisory Committee now conduct joint meetings to establish a framework that allows them to better support interagency R&D modernization goals in the areas of safety, efficiency, and environment and energy.

Recent REDAC recommendations appear in Appendix A of this Plan.

1.4 Recent Aviation Community Initiatives

All FAA initiatives described in this section relate directly to the agency's pragmatic approach to NAS Modernization. In their planning and execution, they are "benefits-driven," involve all facets of the user community, try to lessen implementation risk, and depend heavily upon past, current, and future R&D efforts. In philosophy, the are consistent with the Free Flight operational concept, "...a safe and efficient flight operating capability, under instrument flight rules, in which the operators have the freedom to select their path and speed in real time."

All are based on Administrator Garvey's "three essential goals" of modernization:

- Sustain the integrity and reliability of the system.
- Improve on our Nation's excellent safety performance.
- Increase flight efficiency and flexibility.

1.4.1 NAS Architecture

The NAS Architecture responds to the requirements of the *Government/Industry Operational Concept for the Evolution of Free Flight* (CONOPS). The most recent version culminates an intensive effort of the FAA, DOD, industry representatives, and pilot and owners' organizations to define a realistic comprehensive system architecture to meet the infrastructure needs of 21st-century air transportation. The *NAS Architecture Version 4.0* document, approved by the FAA Joint Resources Council on September 14, 1998, was published in February 1999.

The Architecture incorporates the needs and requirements of NAS users and directs an incremental, benefits-driven approach towards the capabilities of Free Flight. It covers the transition from the current NAS through three distinct phases respectively ending in: 2002; 2007; and the year when mature Free Flight is anticipated, 2015. The concept forms the basis for various FAA and user community plans calling for procedural, financial, and architectural decisions regarding capabilities needed for Free Flight.

Before the full Architecture was put together, a NAS Modernization model was used to validate all current and proposed R&D initiatives within the Air Traffic Services (ATS) area. As a result, new requirements were identified, and some ongoing research activities were restructured. Details of how ATS research activities map to NAS Modernization appear in the *NAS Architecture Version 4.0.* As system managers continue to anticipate future needs, they will continue to assess architecture options against the NAS Modernization model and existing capabilities.

1.4.2 Free Flight Initiatives

Free Flight Phase 1

The partnerships, systems, and regulations that will make Free Flight both safe and efficient will be developed in the "phases" described in Section 1.4.1, "NAS Architecture." Free Flight Phase 1 (FFP1) was begun in July of 1998. As a "Phase 1" effort, FFP1 will be completed by calendar year 2002. In its short span of time, FFP1 will deploy its "core capability" prototype systems to selected sites, in specific configurations to demonstrate the potential of adapting known research vehicles to meet the steep capacity and efficiency demands of the Free Flight environment. The FAA and its partners have maintained consensus on the FFP1 core capabilities and their limited deployment (CCLD). They have collaboratively endorsed the statement: "Any activity that removes restrictions represents a move toward Free Flight."

The FFP1 consensus between the FAA and the full aviation community has been extraordinary. RTCA took an early and active role in bringing other partners in industry into the collaborative process. Various committees and task forces operating in the four years prior to the start of FFP1 did a great deal to define the issues and shape the program. The FAA Administrator established the program as a high priority, high visibility undertaking, accountable directly to her office.

The basic goals of FFP1 are to: (1) provide near-term measurable benefits; (2) focus on early delivery of operational capabilities by the year 2002; (3) integrate the capabilities with procedures; (4) utilize "low risk" technologies; (5) use an evolutionary development paradigm; (6) integrate operational, technical, and financial considerations; and (7) measure results (provide metrics) and maintain accountability.

The selected FFP1 capabilities are:

- Traffic Management Advisor (TMA): A tool that aids the enroute controller in making decisions regarding sequencing and spacing of enroute arrival aircraft approaching selected airports.
- Passive Final Approach Spacing Tool (pFAST): A tool that aids the controller in making decisions regarding sequencing and runway assignment for terminal arrival aircraft.
- User-Request Evaluation Tool (URET): A tool that aids the controller in managing enroute traffic, supporting user request decisions, and identifying potential conflicts.
- Collaborative Decision making (CDM): A collection of tools that allows the FAA and participating airlines to exchange NAS status information including weather, equipment and delays.
- Surface Movement Advisor (SMA): A data distribution capability that provides aircraft arrival information to airline ramp towers and permits data exchange to support efficient surface movement.

Figure 1-3 graphically depicts the interaction of the FFP1 CCLDs in all phases of flight.

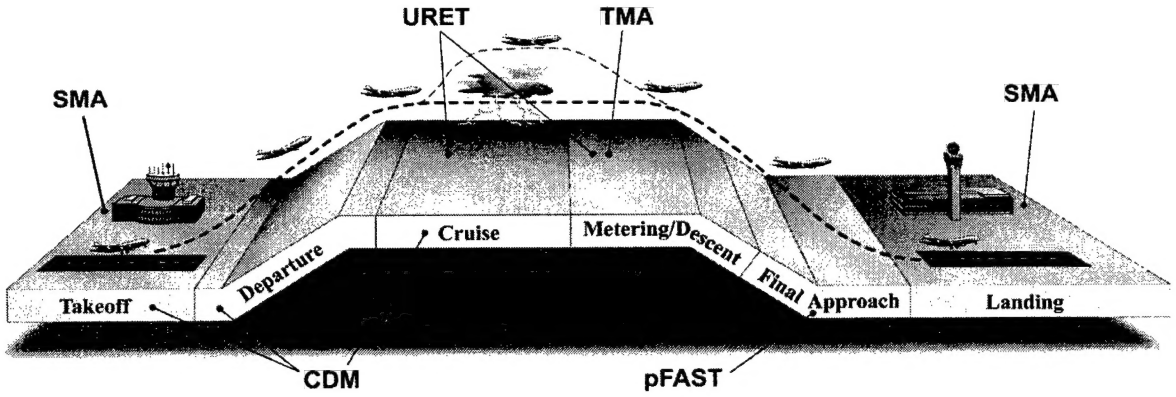

Figure 1-3. Free Flight Phase 1 CCLDs

The Free Flight Phase 1 program represents a strong confirmation of the value of existing and ongoing aviation systems research. The program is now delivering the early benefits and maintaining the metrics required in its charter. As of October 1999, the FFP1 "products" have made impressive progress, including the following:

- TMA: Early prototypes have been deployed to Miami, Los Angeles and Denver Centers; the current build prototype is fully operational at Ft. Worth, where it is being used whenever conditions warrant.
- pFAST: The current prototype has been deployed at Dallas Fort Worth.
- URET: Prototypes have been deployed at Memphis and Indianapolis Centers; two-way host interface operations continue to increase at both centers, indicating increasing controller acceptance.
- CDM: 13 of 21 facilities are configured for Initial Collaborative Routing; the Enhanced Ground Delay Program Flight Schedule Monitor is installed at 27 of 34 field facilities; system-wide, over 3.2 million minutes of delay have been avoided between 9/98 and 9/99.
- SMA: Non-FFP1 prototype still supported in Atlanta; all FY99 milestones were completed ahead of schedule; SMA data is being provided from Detroit (to Northwest Airlines and Southwest Airlines) and Philadelphia (to US Airways).

Safe Flight 21

As with FFP1, Safe Flight 21 is a high-priority Phase 1 activity intended to accelerate the pace and success of NAS modernization. Safe Flight 21 has replaced and redefined the Flight 2000 program. With the collaboration of the aviation industry, the program has targeted nine communications, navigation, and surveillance operational enhancements to deploy and evaluate within the Ohio Valley, in Alaska, or in both locations. The results will provide a basis for future FAA policies and decisions regarding the selected technologies and procedures.

By the end of FY 2000 the Safe Flight 21 Program Office intends to procure and install Automatic Dependent Surveillance – Broadcast (ADS-B) ground stations; Flight Information Services (FIS) and the Automated Weather Observation System (AWOS) in Alaska; and avionics in FAA and Alaska aircraft. In this same time frame, the staff will complete an evaluation of the three selected ADS-B links, submit their recommendations regarding optimal link choices, and begin to develop related procedures.

1.4.3 New Safety and Security Initiatives

Safer Skies

In 1997 the President's Commission recommended the FAA launch a concentrated effort to reduce accidents fivefold over the next decade. The National Civil Aviation Review Commission (NCARC) concurred and further advised that the FAA work with industry on safety data analysis. Later that year, Administrator Garvey committed the agency to developing a five-year plan to focus its resources on the accident prevention steps that hold the greatest potential. "Safer Skies" was the result. The essence of the initiative was to look at available data and to draw lessons from it—a pointed, pragmatic research emphasis.

Vice President Gore announced the new initiative, "Safer Skies—A Focused Agenda," on April 14, 1998. Under this agenda, the FAA pledged to review available data on all major causes of aviation accidents and, where necessary, refocus its safety priorities. Just a year and a day later, Administrator Garvey was able to report to a conference of industrial participants that 230 aircraft of 13 types were collecting Flight Operations Quality Assurance (FOQA) data and 350 additional aircraft were being equipped for FOQA.

Safer Skies has focused initially on three areas: commercial aviation, general aviation, and cabin safety. In just one year, eight final rules have been published in the *Federal Register* regarding the prevention of uncontained engine failures. Another rule soon will require that passenger aircraft carry warning systems to lessen the dangers of Controlled Flight into Terrain. New standards, awareness training for controllers, and special training for pilots are imminent. The potential for Safer Skies operational insights is very promising.

Fielding of Security Equipment

Since the early 1990s, the FAA Aviation Security R&D Program has been highly responsive to congressional mandates, as well as the Gore Commission, to expedite the passage from research to the field of cheaper, more reliable aviation security technologies. To date, the FAA Security Equipment Integrated Product Team has advanced the protection of the traveling public by deploying over 531 explosive trace detection devices to U.S. airports. The team already has completed 92 installations of one vendor's advanced explosives detection system (EDS) installations, with more scheduled for FY2000. A recent competitor's EDS was certified in October 1998, and by the end of FY2000, certification of a third vendor's system is anticipated. The agency works closely with its industry partners to encourage constructive competition, to decrease the costs, and to increase the reliable capabilities of fieldworthy systems.

Various types of systems are in, or are nearing, prototype stages to mitigate the security threats involving the full range of aviation facilities and situations. Examples include checked baggage screening technologies, checkpoint technologies, cargo screening technologies, and systems designed for small volume vs. large volume airports and other facilities. While automated solutions are preferred, standards and training programs are being developed to screen and train the airport and airline employee operators of systems.

Aging Aircraft Systems

On October 1, 1998, DOT Secretary Rodney Slater and FAA Administrator Garvey announced a new initiative that will help ensure that aircraft systems such as wiring and fuel do not fail as they age. This program, called the Aging Transport Nonstructural System Plan, includes stepped-up inspections of wiring, a long-term research program, and a model-by-model assessment of each aircraft type. The initiative was undertaken in response to the mandate of the Gore Commission.

The FAA's nonstructural aging aircraft program combines regulatory actions, focused inspections, research, training, and advice from the aviation community. It includes seven initiatives to enhance the safety of nonstructural aircraft components:

1. Establish an Aging Transport Systems Advisory Committee to coordinate the Plan's initiatives.

2. Conduct an in-depth review of the aging transport fleet and make model-specific safety recommendations related to airplane systems.

3. Enhance airplane maintenance to better address aging airplane systems.

4. Add aging systems tasks to the FAA research program.

5. Improve reporting of accident/incidents and maintenance actions involving aircraft wiring system components.

6. Evaluate the need for additional maintenance of transport airplane fuel system wiring and address any unsafe conditions.

7. Improve wiring installation drawings and instructions for continuing airworthiness.

In recent years, the Aging Aircraft Program has constructed one state-of-the-art testing facility and added to another. The new full-scale aircraft structural test evaluation and research facility at the William J. Hughes Technical Center examines full-scale curved panel specimens under actual operating conditions and provides data to validate the FAA's analytical models. The expanded Airworthiness Assurance Nondestructive Inspection Validation Center, in Albuquerque, New Mexico, compares and evaluates the effectiveness of inspection, maintenance, and repair techniques. The program also has begun several data collection programs and data surveys to determine the actual effects of wear upon aircraft under routine operating conditions.

1.5 Research Partnerships

1.5.1 National Science and Technology Council

President Clinton established the National Science and Technology Council (NSTC) by Executive order on November 23, 1993. This Cabinet-level Council is the principal means by which the President, who chairs the NSTC, can coordinate science, space, and technology among the diverse parts of the Federal research and development enterprise. Council members include the Vice President, Assistant to the President for Science and Technology, Cabinet Secretaries and Agency Heads with significant science and technology responsibilities, and other White House officials.

A key NSTC objective is to establish clear national goals for Federal science and technology investments that can strengthen and improve areas ranging from information technologies and health research to transportation systems and fundamental research. The Council prepares research and development strategies that are coordinated across Federal agencies to form an investment package aimed at accomplishing multiple national goals.

The NSTC Committee on Transportation Research and Development chaired by Deputy Secretary Mortimer Downey has developed the rationale and framework for guiding Federal initiatives that will make the transportation system safer, more productive, and more efficient. Considering the likely future, the Transportation R&D Committee has defined these strategic goals for transportation R&D:

- Provide a safer transportation system.
- Achieve a high level of transportation system security.
- Improve environmental quality and energy efficiency.
- Foster economic growth and productivity through more effective and flexible global passenger and freight services.
- Ensure improved access to and increased mobility on the Nation's transportation system.

The FY 2001 FAA R&D budget supports these strategic goals for transportation R&D in the NSTC plan. The FAA is a highly visible member of the transportation community. Continuing investments in its research activities are critical to meeting the national goals and sustaining the prosperity of the national economy.

In its recently published report titled *'National Research and Development Plan for Aviation Safety, Security, Efficiency, and Environmental Compatibility'* (1999), the Council provides a description of the coordinated long-term research initiatives it believes are needed to bring about the advances in aviation for the opening decades of the next century. The report is available on the internet at:

http://www.volpe.dot.gov/resref/strtplns/nstc/aviatrd

1.5.2 FAA/NASA Collaborative Research

FAA/NASA Safety Program

The pace of aviation is changing so rapidly that, in less than two decades, there could be a fatal airline accident somewhere in the world every week — unless the FAA and its research partners lower the accident rate. Technology has always held the key to maintaining commercial aviation's impressive safety record, but in an increasingly complex world, the search for technologies requires increasing discipline. The wrong technologies, employed in the wrong ways, could introduce more problems than they solve.

On October 9, 1998, FAA Administrator Jane Garvey and NASA Administrator Daniel Goldin signed a formal agreement to articulate and achieve specific joint goals enabling the NAS to meet its future challenges. The agencies have long worked together through Memoranda of Understanding on specific topics such as human factors, aging aircraft, aircraft icing, airworthiness of new classes of aircraft, crashworthiness, energy efficiency, and noise reduction. Since 1980, each of the agencies has provided members to a common R&D coordinating committee. With the 1998 agreement, that committee was restructured into a new "FAA/NASA Executive Committee" and charged with coordinating all joint R&D efforts.

The FAA has traditionally developed and implemented technologies, regulations, and procedures based upon its supporting research. These innova-

tions have provided operational benefits to areas including security, efficiency, and environmental compatibility, in addition to safety. NASA has complemented FAA's role by conducting research, development, verification and transfer of advanced technologies that have enabled long and short-term NAS improvements. These remain the roles emphasized for the agencies by the 1998 agreement.

The recent NSTC National R&D Plan (cited in Paragraph 1.5.1 of this Plan) provides an "Aviation Safety Roadmap" of the inter-agency plan to achieve the national goal for safety. The initiative has three primary thrusts and entails the following research issues:

Accident Precursor Identification and Safety Risk Management — Accidents rarely have a single cause. Aviation systems and procedures, accordingly, are developed to be redundant and failure-tolerant. Many accidents can be avoided by detecting and responding to anomalous operating conditions. The FAA is looking into means to obtain data for the prevention of accidents through its Aviation Safety and Risk Analysis (ASRA) program. NASA's Aviation System Data Monitoring and Modeling (ASMM) program identifies tools and methodologies that not only can analyze situations today but also foresee the future safety impact of today's changes to key systems. Jointly, the agencies are working to develop the Aviation Performance Measuring System (APMS) to help all segments of the aviation community draw safety implications out of the data now being collected as a normal part of fleet operations.

Accident prevention — The FAA conducts research to help it establish safety-related rules, regulations, and advisory materials. Through its research, NASA identifies and develops on-board and system-wide technologies that can keep aircraft safe. FAA is working closely with industry in aviation safety areas including the improvement of propulsion and fuel systems, the prevention of aircraft catastrophic failure, the elimination or containment of in-flight fires, and the creation of safer airport materials and systems. NASA research is upon technologies to afford better visibility to pilots and flight crews experiencing adverse conditions, to improve the overall health of pilots and crews, and to allow pilots to regain control of their aircraft when engines or systems fail in flight. Together with DOD, the FAA and NASA are working to improve the effectiveness of their long-term commitment to the Aging Aircraft program.

Accident Mitigation — When aviation accidents do occur, their effects can be lessened through attention to factors such as aircraft crashworthiness, occupant protection, fire safety, evacuation equipment and procedures, and airport emergency services. The FAA is conducting detailed and innovative aeromedical research to improve the chances that more passengers and crew members will survive aviation accidents. The agency also works to improve airport systems to provide better materials, methods and equipment to increase survival rates. NASA partners with the FAA on research to improve the structural crashworthiness and the fire resistance of aircraft and fuels.

Integrated Plan for Air Traffic Management for Research and Technology Development

On September 11, 1995, the FAA and NASA strengthened their partnership by signing a Memorandum of Understanding on Airspace System User Operational Flexibility and Productivity, thus initiating the formation of the FAA/NASA Interagency Air Traffic Management (ATM) Integrated Product Team (IAIPT). ATM encompasses air-based and ground-based air traffic control and traffic flow management decision support tools and procedures. This cooperative relationship was reaffirmed on October 9, 1998 with the signing of the "Agreement Between DOT/FAA and NASA Concerning a Partnership to Achieve Goals in Aviation and Commercial Space Transportation."

The stated mission of the IAIPT is to maintain the safety of aircraft operations for the current and future NAS while planning and conducting integrated FAA/NASA ATM R&D leading to the implementation of operational concepts and associated decision support tools that enhance the efficiency, capacity, and flexibility of the National Airspace System.

The IAIPT is comprised of the major stakeholders in the planning, execution, and outcome of ATM R&D programs, throughout the FAA and NASA.

As illustrated in Figure 1-4 below, the three major elements of the IAIPT are: 1) the IAIPT Co-Leads, 2) the Interagency Integrated Management Team (IAIMT), and 3) Area Work Teams (AWT).

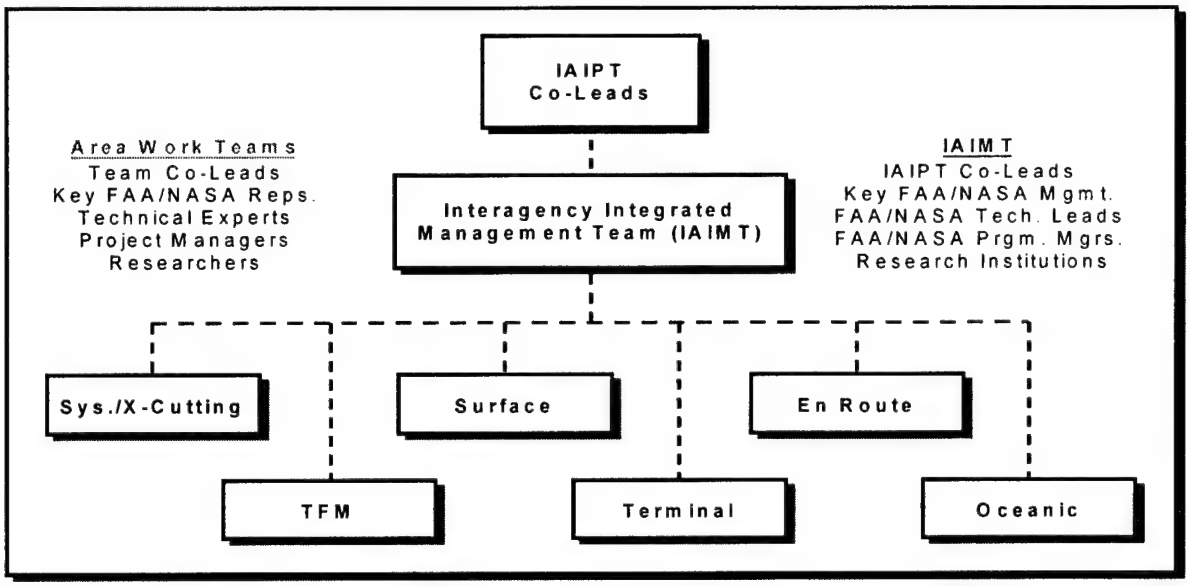

Figure 1-4. IAIPT Organization

The IAIPT Co-Leads strategically formulate R&D policy and goals that effectively position the IAIPT to achieve its mission. The IAIMT ensures that R&D outputs result in highly useful ATM products for customers and stakeholders. The AWTs execute specific research activities in each of the research areas encompassed by the IAIPT. Together, these elements provide structure and means for communications and resolution of issues as well as integration across research domains.

IAIPT receives guidance from the FAA R,E&D Advisory Committee (REDAC), its Subcommittee on Air Traffic Services, the NASA Aeronautics and Space Transportation Technology Advisory Committee, and the NASA Air Traffic Management Research and Development Executive Steering Committee. Through its respective FAA and NASA organizations, the IAIPT also maintains collaborative partnerships with Federally-Funded Research and Development Centers, industry, academia, Department of Defense, Eurocontrol, the Center of Excellence in ATM and Operations Research, the National Weather Service, and research contracts.

The principal defining documents for the IAIPT are the *Integrated Plan for Air Traffic Management Research and Technology Development* (Version 3.0) and the *Management Plan for the FAA/NASA Interagency Air Traffic Management Integrated Product Team* (Version 1.0b). The six IAIPT AWTs, representing the technical domains of ATM R&D, are as follows:

- *System/Cross-Cutting*—System-wide initiatives, including the initial definition of concepts and assessment methodologies and demonstrations of cross-domain system(s) integration (e.g., enroute, terminal, and surface decision support systems).
- *Traffic Flow Management*—Strategic resource allocation and flow management.
- *Surface*—Operations on an airport's surface.
- *Terminal*—Operations in airspace surrounding one or more closely spaced airports where a TRACON or a comparable military facility provides services.
- *En Route*—Operations in airspace between airports where an ARTCC provides services, and transition airspace between the enroute and terminal environments.

- *Oceanic*—Operations in airspace over international waters where an oceanic ARTCC provides services.

The IAIPT periodically reports to the FAA Associate Administrator for Research and Acquisitions and the NASA Associate Administrator for Aerospace Technology through the FAA/NASA Coordinating Committee. Specific program direction and control comes through internal program management mechanisms in both agencies.

Joint ATM research is accomplished through Joint Research Project Descriptions. Currently, 22 JRPDs comprise the IAIPT research program and are contained in the IAIPT Integrated Plan. IAIPT research is accomplished at the following research facilities: FAA William H. Hughes Technical Center, NASA Ames Research Center, NASA Langley Research Center, MITRE CAASD, MIT Lincoln Laboratory, Volpe National Transportation Systems Center, and NASA North Texas Research Station.

All of FAA's current Free Flight Phase 1 core capabilities for limited deployment (see Section 1.4.2) have successfully been transitioned from former IAIPT products.

IAIPT joint FAA and NASA near- and far-term research is currently being conducted on the products shown in Table 1-2.

Table 1-2 Current and Envisioned FAA/NASA IAIPT Products

IAIPT Product	Description (if available)
Multi-Center Traffic Management Advisor (McTMA)	Provides aircraft sequencing and scheduling to enable efficient departure taxiing and climbs.
Surface Management System (SMS)	Advises airlines, ramp controllers, and air traffic control on push-back and taxi navigation for efficient surface operations.
Expedite Departure Path (EDP)	Coordinates departure sequencing and scheduling to enable efficient departure taxiing and climbs.
Collaborative Routing Coordination Tool (CRCT)	Vehicle for making collaborative decisions concerning flow-constrained areas and impacted flights.
Collaborative Arrival Planner (CAP)	Communicates airline operation center user preferences and arrival handling preferences to air traffic control.
Future Collaborative Decision Making Tools	Improved demand and constraint prediction algorithms and enhanced integration of weather predictions into strategic traffic flow planning.
Distributed Air-Ground Traffic Management (DAG)	Provides distributed decision making information to flight deck crews, air traffic service providers, and aeronautical operations control facilities to enable user preferences and increase system capacity.
Airborne Planner to Avoid Traffic & Hazards (APATH)	Provides aircraft flight crew with tactical situational awareness of surrounding traffic enabling efficient self-separation.
Active Final Approach Spacing Tool (aFAST)	Provides arrival aircraft speed and heading advisories to the TRACON arrival controllers.
Direct-To (D2)	Advises sector controllers of time saving direct routing options for aircraft within an ARTCC.
Problem Analysis, Resolution, and Ranking (PARR)	Provides conflict resolution enhancements to User Request Evaluation Tool (URET) that enable strategic detection of conflicts and support user request decisions.
En Route Descent Advisor (E/DA)	Provides advisories to ARTCC sector controllers on merging, sequencing, and spacing of aircraft for efficient climb, cruise, and descent constraint and flow management.

The IAIPT Integrated Plan is available on the Internet: ftp://awaauatac2.faa.gov/IAIPT_Main/IAIPT_Public

1.5.3 Cooperative Research

The work described below is representative of partnering between the FAA, NASA, and primary DOD components in planning, funding, and the use of cooperative agreements.

Aircraft Modification and Improvement Research

FAA programs to improve the initial and continuing airworthiness and survivability of aircraft have benefited from the interest and support of the DOD service branches. The Aging Aircraft program develops information and procedures for using technologies that can predict the onset of failures of aircraft structures under a range of operating conditions.

In addition to FAA and NASA sponsorship, this program receives significant U.S. Air Force funding. The Air Force and FAA are co-participants in funding the Fire Research and Safety program and its efforts to standardize and improve the testing of fire-resistant materials for use in aircraft interiors. Similarly, the Aircraft Hardening program relies on significant U.S. Navy participation to develop protection for aircraft against catastrophic structural or critical system failures resulting from in-flight explosions or the effects of electronic interference.

DOD also is vitally interested in the development of flight standards underlying the Safety Performance Analysis System (SPAS), which provides FAA stakeholders with critical safety-related data on the design, maintenance, and operation of their aircraft.

Human Factors Research

Along with FAA and NASA, DOD is a primary participant in publishing the *National Plan for Civil Aviation Human Factors—An initiative for Research and Application.* This document outlines a coherent national agenda for human factors research and application leading to significant improvements in NAS safety and efficiency. Programs stemming from this and similar research plans have developed and provided useful information to FAA stakeholders on the effects of human performance on aviation operations, navigation, aircraft maintenance, and other matters of importance to commercial and military aviation. Section 1.7.1 of this Plan provides an overview of some of the sophisticated human factors research projects being carried out at the FAA's William J. Hughes Technical Center and Civil Aeromedical Institute.

1.5.4 Centers of Excellence

Air Transportation Centers of Excellence (COE) are established through cooperative agreements among academic institutions, their affiliate partners, and the FAA. COEs are established to assist the FAA in the pursuit of mission-critical research in technologies that are pertinent to developing and maintaining a safe and efficient national air transportation system. Centers may be funded in 3 phases over a period of three to ten years. Thereafter, they are expected to be self-supporting.

Center of Excellence in Airworthiness Assurance

The Center in Airworthiness Assurance was established with Ohio State University and Iowa State University as leads and seven additional core members. There are more than 100 academic, industry, and government affiliate partners.

The center, established in September 1997, conducts research in the areas of:

- Maintenance, inspection, and repair.
- Crash-worthiness.
- Propulsion and fuel systems performance.
- Safety.
- Advanced materials.

Funded through contracts and grant awards, this center has a $100M contract cap over the next ten years and is making a $500K per year minimum commitment to fund basic and advanced research through a cooperative agreement.

Center of Excellence in Operations Research

The FAA-selected team of the University of California (Berkeley), Massachusetts Institute of Technology, Virginia Polytechnical Institute, and the University of Maryland (College Park) are the leads for the Center of Excellence in Operations Research. This team includes ten university affiliates and twenty industrial partners. The COE program uses a new funding vehicle blending grant and sole-source contracting authority to award a wide range of contracts. The center's areas of re-

search involvement include traffic management and control, human factors, system performance and assessment measures, safety data analysis, scheduling, workload management and distribution, navigation, communications, data collection and distribution, and aviation economics.

Center of Excellence for Airport Pavement Research

The Center of Excellence for Airport Pavement Research was established with the University of Illinois (Urbana-Champaign) in April 1995 and is supported by Northwestern University. Pavement research focuses on new technologies to handle the estimated stress loads foreseen in the next generation of high-volume, commercial aircraft, such as the Boeing 777. This research, including rehabilitation and non-destructive testing and evaluation of existing pavement, is conducted at the former Chanute Air Force Base, Rantoul, Illinois.

1.5.5 European Activity

Global harmonization of communication, navigation, surveillance, and air traffic management (CNS/ATM) technologies and standards holds the key to the future success of all aviation systems. The United States (through the FAA) continues to position itself to be a leader in international efforts to maintain the safety, security, efficiency and environmental compatibility of civil aviation. Progress towards a globally harmonized CNS/ATM system has accelerated since the adoption of the Global Plan for CNS/ATM Implementation by the International Civil Aviation Organization's (ICAO) Tenth Air Navigation Conference.

The FAA has continued to support CNS/ATM implementation by participating in ICAO technical panels, committees, study groups, and regional planning groups as well as by entering into numerous bilateral cooperative research and development agreements with countries and civil aviation organizations in every region of the world. These ICAO forums and international agreements provide the FAA opportunities to work directly with key research, engineering, and development organizations and decisionmakers in order to make significant contributions toward international coordination of air traffic services.

The FAA also works closely with internationally recognized standards developing organizations such as RTCA and the European Organization for Civil Aviation Equipment (EUROCAE) to reach consensus with industry and the user community on standardizing and certifying evolving aviation technologies.

1.6 Overview of the R,E&D Program

The FAA RE,&D program is divided functionally into seven areas: Air Traffic Services, Airport Technology, Aircraft Safety, Aviation Security, Human Factors and Aviation Medicine, Environment and Energy, and R,E&D Program Management.

- *Air Traffic Services*—R&D focuses on increasing system safety and capacity and enhancing the flexibility and efficiency of air traffic management operations. A key element in achieving these objectives is developing decision support tools that will enable FAA air traffic specialists to manage traffic flows more efficiently while collaborating with the user community in making decisions affecting their operations.

  The R&D program is also working to reduce the risks of runway incursions, midair collisions, and aircraft encounters caused by the effects of wake vortices and hazardous weather. Research is developing new technologies that will improve navigational accuracy and provide improved landing guidance. Communication research develops technologies that improve the reliability of pilot-controller communications and permit the exchange of large data files, such as weather data, to pilots.

  The FAA is introducing new technologies to support a Free Flight system, in which aircraft operators could vary their speed and flight path to increase operational efficiency, while air traffic controllers ensure that safety is maintained.

- *Airport Technology*—R&D develops and evaluates technologies and materials designed to ensure and improve safe and efficient operations on the airport surface and in the imme-

diate vicinity of an airport. Research focuses on development and evaluation of advanced, innovative technologies involving pavement design, construction, and maintenance; airport visual and navigation aids; rescue and firefighting equipment and procedures; runway friction; and wildlife control techniques. Research results are used to update FAA standards for the design, construction, and operation of airports and airport equipment, and are incorporated into guidance material used by airport operators, consultants, and equipment manufacturers.

- *Aircraft Safety*—R,E&D focuses on ensuring the safe operation of inservice aircraft. It addresses the hazards to all aircraft in service, as well as the special hazards endemic to select portions of the civil aircraft fleet. Older aircraft are more susceptible to structural problems associated with fatigue and corrosion. New aircraft with digital flight control and avionics systems and associated imbedded software are more susceptible to disruption from external electromagnetic interference. Research focuses on developing technologies and standards for maintenance and modification of inservice aircraft to ensure continued airworthiness. It includes research in structural integrity of airframes and engines, maintenance and repair of composites, atmospheric hazards, crashworthiness, fire safety, and forensics capabilities to support accident investigations.
- *Aviation Security*—R&D develops technologies and standards that counter the threat of terrorism and criminal acts targeted at aviation. Research focuses on developing and evaluating passenger, baggage, mail, and cargo screening devices to detect concealed explosives and weapons; aircraft hardening techniques to increase aircraft survivability in the event of an inflight explosion; human factors aspect of detection and alarm resolution; and integration of airport security technologies and procedures. An important consideration in this research is to develop effective, reliable technologies and procedures that have minimal impact on airport and airline operations.
- *Human Factors and Aviation Medicine*—R,E&D directly supports the National Plan for Civil Aviation Human Factors and the validated needs of the FAA's lines of business and NAS users. The program addresses major human factors priority areas related to the flight deck, ATC, flight deck/ATC system integration, airway facilities, aircraft maintenance, and aeromedical aircraft cabin environments.
- *Environment and Energy*—R&D develops technical information, standards, and procedures to mitigate the environmental impact of aircraft operations (in particular, noise and air pollution emissions), and to better understand and manage the impact of FAA operations on the environment.
- *R,E&D Program Management*—includes the management, planning, control, and support activities associated with formulating the FAA R&D program. These efforts ensure that the program is a cohesive and integrated effort, consistent with the FAA strategic goals and objectives, and fully coordinated with stakeholders and customers.

This cross-cutting emphasis ensures outside assessment of the FAA R&D investments through active participation of the FAA R,E&D Advisory Committee. The members of the committee represent industry, academia, and other government agencies. R,E&D Program Management also facilitates research partnerships with industry, universities, and other government agencies that enable the FAA to leverage its research dollars.

1.7 Long-Term Research

The Research, Engineering, and Development Management Reform Act of 1996 directed the FAA to identify the allocation of resources among long-term research, near-term research, and development activities.

Long-term research, as defined in the Aviation Safety Research Act of 1988, is a research project that is "unlikely to result in a final rulemaking action within five years, or in the initial installation

of operational equipment within 10 years after the date of the commencement of such project."

The FAA's R&D is principally associated with applied research. That is leveraging off new technologies identified by research programs in space, aeronautics, communications, computer science, and other related fields of exploration. Developmental activities beyond this stage are found in the Engineering, Development, Test, and Evaluation activity of the FAA's Facilities and Equipment (F&E) appropriation.

Of the $156,495M appropriated for R&D efforts in FY 2000, 28% of these funds are earmarked for long-term research, with the remainder devoted to developmental/near-term efforts. Similarly, the $184,366M FY 2001 congressional budget submission for R&D designates 23% of the total request for long-term research.

1.7.1 FAA Aviation Research Centers

The FAA maintains two permanent, world-renowned research centers, The Civil Aeromedical Institute, located in Oklahoma City, Oklahoma, and the William J. Hughes Technical Center, located adjacent to the Atlantic City International Airport in New Jersey.

Civil Aeromedical Institute

The Civil Aeromedical Institute (CAMI) is a unique, internationally recognized aeromedical facility located at the Mike Monroney Aeronautical Center in Oklahoma City, Oklahoma. CAMI maintains a cadre of in-house scientific specialists whose safety research thrusts are all distinctively human-centered and include:

- *Advanced ATC Systems Research* — Using rapid prototyping techniques with advanced real-time ATC simulation capabilities, scientists analyze advanced ATC system designs and their effects on workload and performance, develop metrics of performance and workload, assess the applications of innovative control and design concepts, and identify and evaluate the applications of intelligent systems to enhance aviation safety.
- *Behavioral Stressors Research* — Human factors researchers investigate variables that could compromise safety by impairing both ATCS and pilot job performance levels (e.g., shift management, age, fatigue, drug and alcohol induced impairment, color perception) and assess the effectiveness of policies, procedures, individual coping strategies, and countermeasures to reduce performance decrements and enhance individual performance.
- *Organizational Effectiveness Research* — Through field research, analytic information is developed to measure progress toward achieving agency change goals and for agency guidance on the relative merits of various innovations intended to enhance safety, efficiency, effectiveness, workforce health and satisfaction, and system performance. Relationships between psychological characteristics (e.g., work attitudes, organizational perceptions) and the work environment (e.g., business practices, organizational climate) are explored.
- *Flight Crew Performance Assessment* — General Aviation research emphasizes design of flight deck controls and displays related to emerging technology, development and validation of performance-based criteria for use in certification and regulation, and the successful integration of training devices into existing instructional systems to enhance flight crew performance and reduce accidents and incidents.
- *Selection, Validation, Research and Team Performance* — Researchers use laboratory and field studies to develop scientific evidence of the job validity of criteria within aviation selection and training systems. Cognitive strategies and processes underlying aviation skill acquisition through training are identified and assessment measures of individual and team performance developed to determine effects of advancing technologies on individual and workteam safety, efficiency, and effectiveness.
- *Aircraft Accident Research* — CAMI scientists maintain comprehensive databases and conduct extensive analyses involving the human factors, medical, physiological, and pathological aspects of aviation mishaps. Preventive measures and proactive interventions that will enhance aviation safety in the next millennium are rigorously investigated.

- *Forensic Toxicology Research* — Impeccable procedural integrity and robust toxicological and biochemical analyses of human samples from fatal aircraft accidents are required in support of the National Transportation Safety Board to ensure continuous safety of the NAS. Scientists evaluate the underlying human basis of mishaps to prevent future human tragedy in our transportation systems. State of the art analytical and molecular biological techniques, including DNA analyses, are developed to assist in identifying human causes or influences associated with aviation fatalities.
- *Biodynamics Research* — When failures do arise in aviation, occupant survival may depend directly upon the design of the seating and restraint systems in the aircraft. Evaluating the design of these systems and ensuring their protective characteristics requires both scientific and engineering talents.
- *Cabin Safety Research* — The ability to survive following aircraft related emergencies depends upon the systems, structures and procedures that are developed and investigated in CAMI's aircraft evacuation facility where researchers conduct occupant evacuations from current aircraft configurations and develop evacuation research for larger, more complex aerospace vehicles of the future.
- *Aviation Environment Safety Research* — Breathing and oxygen delivery systems for all aircraft occupants in normal and emergency situations are investigated. Threats to visual integrity and pilot performance from intense light emitters and ground-based lasers are defined. Improved measures of galactic cosmic radiation levels at various altitudes are developed by CAMI scientists to ensure that those who work and travel in the aviation system are not at a disproportionate risk for health problems from radiation exposures.

William J. Hughes Technical Center

The FAA William J. Hughes Technical Center (WJHTC) is one of the world's leading engineering, research, development, and testing facilities for nearly every aspect of aviation. Representative areas of involvement of this diverse and extensive facility include:

- *NAS Modernization* — The center uses currently fielded and newly developed systems to perform R&D encompassing every aspect of air traffic operations. Its laboratories contain current and advanced radar display systems capable of intricate simulations for the testing, development, and evaluation of both air and ground traffic procedures and enroute operational concepts.
- *Services and Operations* — Every NAS service provided by the FAA is either on-site or accessible at the center. The Integration Interoperability Facility (IIF) allows staff to simulate actual operating conditions, including adverse weather, to test and evaluate systems without impacting air traffic operations or ARTCC site personnel.
- *Air Traffic Management* — The powerful capability of the Traffic Flow Management Laboratory allows for a "fast-tracked" development approach ideal for meeting escalating NAS modernization needs without extensive, traditional prototyping.
- *Human Factors* — The multiple "what if" capabilities of the Research, Development and Human Factors Laboratory apply principles derived from the behavioral sciences to plan and test the deployment of next generation NAS capabilities such as displays and workstations. As NAS modernization will increasingly rely on the automation of suitable tasks, improved and reliable computer-human interfaces are critical to the avoidance or mitigation of system-induced operator errors.
- *Navigation and Surveillance* — WJHTC scientists conduct flight tests with actual GPS signals and prototype ground stations to maximize GPS accuracy in connection with LASS and WASS capabilities. Similarly, they perform tests and evaluations of Automatic Dependent Surveillance — Broadcast capabilities to provide reliable aircraft position data to airborne and ground-based users.
- *Communications* — Simulation and live research is being performed to improve the reliability of both voice and digital data (data link) transmission.
- *Terminal Areas* — The improvement of airports' capacity is a difficult problem facing

NAS modernization. Center staff work with simulation tools and test environments to refine proposed changes in takeoff and landing patterns, improvements in lighting and visual aids, and new procedures.

- *Safety and Security* — The Aviation Security Laboratory conducts extensive simulated and live testing in the areas of explosives and weapons detection, aircraft hardening, human factors, and security technology integration to provide the civil aviation system with maximum security while minimizing the adverse impacts on airline and airport operation. The Airport and Aircraft Safety R&D Division conducts research in continued airworthiness using some unique, world-class facilities. Fire and accident testing on aircraft, components, and engines requires very specialized facilities and experienced people. The center's facilities in these and areas such as pavement and full-scale curved panel testing are the finest in the world.

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2.0 PROGRAM INFORMATION

2.1 Air Traffic Services Program Area Description

Mission

The overall mission of Air Traffic Services (ATS) is to ensure the safe and efficient operation, maintenance, and use of the air transportation system today and to increase tomorrow's system safety, capacity and productivity. ATS continually seeks to improve the services it provides by undertaking initiatives to meet current and future demands. The ATS R,E&D program is an overt initiative to ensure a structured and evolutionary improvement of services that keeps pace with the global growth in aviation. The mission of the R,E&D program is to develop technology, practices, and procedures to ensure continued improvement in the delivery of air traffic services.

Intended Outcomes

The ATS R,E&D program is one part of an integrated strategy to increase the value of the air traffic services delivered. The ATS R,E&D program is a vehicle for making long-term investments in improving services, procedures and infrastructure, as well as integrating new concepts and technology able to meet the increasing demands of safety, capacity, efficiency, and productivity. Human factors considerations are central to all outcomes of the program for a totally effective solution. The ATS R,E&D program contributes to the ATS performance outcomes contained in the Air Traffic Services Performance Plan and the strategic goals of Government Performance and Results Acts (GPRA). The program is also consistent with the goals delineated in the FAA Strategic Plan, Research and Acquisitions Performance Plan, and Regulation and Certification Performance Plan.

The ATS R,E&D program contributes to the four performance outcomes described below and represents increased value to the users of the system and the American public.

Improve Quality and Availability of Weather Information — Weather has a continual impact on both the safety of aircraft in flight and the efficiency of operations throughout the National Airspace System (NAS). Weather and weather decision making, factors in approximately 23% of all aviation accidents, annually cost the country an estimated $3 billion for accident damage and injuries, delays and unexpected operating costs. The ATS R,E&D program is striving to improve the accuracy, display, and timeliness of weather information—and also the ability of controllers and pilots to use that information to safely and efficiently. Aviation weather capabilities in the NAS must undergo major changes to improve decision making and reduce the number of weather-related accidents. Specifically, today's weather sensors must be converted to allow all NAS providers and users to receive the same weather information simultaneously.

The ATS R,E&D program is pursuing an aggressive schedule of developing and implementing a variety of technologies for improving the accuracy, timeliness, and usefulness of weather information in combination with extensive training for pilots and ATS personnel on the use of new weather systems.

Research is needed to measure how weather information enhances decision making and reduces fatalities/injuries caused by weather. ATS is currently collecting and analyzing data to demonstrate the capability of new weather technologies to decrease the rate of weather delays in the NAS.

Reduce Delays — The traditional measure of the efficiency of the ATM system is delay. Delay occurs in the aviation system when an activity does not happen within the planned, expected, or scheduled time. Delays to commercial aviation are estimated to cost the airlines over $3 billion per year. The inconvenience of delays directly affect passengers in terms of missed flight connections and business meetings, and loss of personal time. But not all delays are avoidable. Adverse weather, for example, can close a runway or whole airport, making it impossible to land at the scheduled time. ATS, therefore, differentiates between and tracks delays caused by ATC equipment and volume as well as by weather and factors over which is has less control. ATS recognizes that any delay is a disruption in the expected level of service and is committed to reducing all delays to the fullest extent possible.

Service improvements during the 2000-2002 timeframe will focus on Free Flight Phase 1 tools, new runways, and critical infrastructure replacement programs. Airspace and airport capacity will be enhanced to improve throughput and allow aircraft to operate with minimal delay in congested areas. ATS will reduce equipment-related delays by implementing AF's NAS Service Management Concept of Operations, and effectively conducting new risk management and risk mitigation processes.

Continuing to involve users in key decisions regarding national ground delay programs will reduce the impact of weather on flight schedules. While delays associated with weather are harder to influence, the ATS R,E&D program is continuing to support collaborative decision making and the implementation of automated detection and forecasting tools to mitigate the negative impact of these delays.

Improve System Predictability — System predictability allows users to plan and manage their resources efficiently. The majority of system users rely on schedules that define when aircraft takeoff and aircraft land. These schedules are central to the operations of most commercial flights, driving crew scheduling, ground service operations, and other operational components. Near-term decisions such as scheduling and planning flights—as well as longer-term decisions such as fleet sizes, airframe types and hubbing options—are all impacted by day-to-day variation in NAS performance. Because relatively small deviations from scheduled operations can cause drastic impacts, especially when ripple effects throughout the system are taken into account, scheduled operations are very dependent on system predictability.

The ATS R,E&D program is working toward increasing information flow to system users, a key ingredient to improved system predictability. Collaborative planning between ATS and all NAS users is a strategy being pursued during the 2000-2002 timeframe. As weather is a main contributor to the uncertainty in the ATM system, improvements are being undertaken in obtaining and disseminating weather products. These improvements will supply consistent information to pilots and controllers alike so that they can realize the same degree of situational awareness.

Improve System Flexibility — Measuring the flexibility of the ATM systems allows ATS to evaluate its own ability to permit users to adapt their operations to changing conditions. Users want to be able to optimize their operations based on their own objectives and constraints. These constraints can vary flight-by-flight and user-by-user.

ATC-preferred routes are important tools that help air traffic controllers to organize traffic flows around major airports and minimize conflict in congested airspace. These routes are generally not the most direct alternatives, and often differ significantly from the routes that pilots or flight planners would normally propose between two cities. Due to the constraints of ATC-preferred routes, users sometimes experience inflexibility during the flight planning process, especially when planning flights along heavily traveled corridors. Flexibility in flight planning offers users significant benefits. Once an aircraft is airborne, the very conditions for which a route and altitude were chosen may change. For example, winds may shift to make another route more desirable. The parameters that affect an optimal flight are very dynamic, and ATS options must be equally flexible.

For increased flexibility of flight operations in the NAS, the ATS R,E&D program will continue to evolve its services toward the free flight concept of operations and work with aviation users in the review and redesign of the national airspace.

Program Area Outputs

The developmental outputs of the ATS R,E&D program vary in composition from operational prototype equipment to operational concepts, modeling and simulation studies, emergent technology evaluations, and procedures, standards and guidance. Some specific examples of expected outputs for the ATS R,E&D program follow:

- Uplink of guidance information that will give aircraft and controllers the same situational awareness.
- Timely delivery of high-resolution information for icing, winds, temperature, and turbulence to improve aviation advisories and forecasts used by the National Weather Service.

- Human factors guidelines for shared information displays in air-to-ground communications.
- Selection criteria and training methods for operators and maintainers that reflect changes in the operational environment and automation.
- Support to industry development of advanced avionics for small airplane and rotorcraft single pilot in flight rules (IFR) to meet FAA requirements.
- Improved processes and practices in software development for the aviation industry and the FAA.
- Guidelines for an effective, accelerated system/software to production process.
- Refinement of airborne collision avoidance technologies and procedures.

Program Area Structure

The ATS R,E&D program has been structured to systematically support the following intended outcomes:

- Improve Quality and Availability of Weather Information
- Reduce Delays
- Improve System Flexibility
- Improve System Predictability

The ATS R,E&D program addresses these outcomes, and strives to make the most efficient and effective possible use of R,E&D resources, with the objective of adding value to benefit NAS users, operators, and the public.

Customer and Stakeholder Involvement

The ATS R,E&D program reaches and supports the interests of a broad spectrum of the aviation community, including those reflected in the Aviation Safety Plan, RTCA Free Flight Action Plan, and the NAS System Architecture Development and the ATS Concept of Operations for the National Airspace System in 2005. Specific examples of customer and stakeholder involvement include:

- The R,E&D Advisory Committee (REDAC) provides guidance on the FAA's ATS investments. The REDAC Subcommittee for ATS reviews the ATS program and provides recommendations on ATS R,E&D investments. This program has seriously considered the Subcommittee's recommendations and has adopted much of their advice;
- The National Plan for Aviation Human Factors represents a cooperative effort between the FAA, NASA and DOD to establish a coherent national agenda for human factors research and development to improve the safety and efficiency of the NAS; and
- The National Aviation Weather Users' Forum provides a process to develop a federal/industry consensus on the needs and priorities for aviation weather information and serves as a basis for setting priorities for research and development. Forum attendance includes representatives from:
  - The Airline Pilots Association (ALPA)
  - Airline Dispatchers Federation (ADF)
  - Air Transport Association of America (ATA)
  - Aircraft Owners and Pilots Association (AOPA)
  - Experimental Aircraft Association (EAA)
  - Helicopter Association International (HAI)
  - National Air Transportation Association (NATA)
  - National Association of State Aviation Officials (NASAO)
  - National Business Aircraft Association (NBAA)
  - Regional Airline Association (RAA)
  - American Airlines
  - Delta Airlines
  - Other facets of industry

Accomplishments

The following represents a partial listing of recent past accomplishments of the ATS R,E&D program:

- Developed prototype methodology to evaluate the impact of technological and Concept of Operations change on controller selection requirements.

- Completed Weather Support to Deicing Decision Making (WSDDM) technology transfer to commercial vendor for operational implementation.
- Implemented in-situ turbulence algorithm on multiple airframes.
- Completed convective weather forecast algorithm commercial technology transition.
- Completed national implementation of next generation weather radar (NEXRAD) Tornado Detection algorithm.
- Completed Standard Terminal Automation Replacement System (STARS) Early Deployment Capability Human Factors evaluation.
- Conducted Data Link Evaluation Simulations and Studies.
- Commenced design of a sensor for parallel runway wake turbulence sensing.
- Integrated terminal area weather products with automatic updates for airborne aircraft through use of Flight Information Service (FIS) broadcasts.

R&D Partnerships

The ATS R,E&D program established, and continues to establish, partnerships with U. S. Government agencies, international organizations, academic institutions, the airline industry, industry and industry user groups, and non-profit organizations. A listing of some of the current partnerships is enumerated below:

- U.S. Government Agencies:
  - Department of Commerce
  - Department of Defense
  - National Aeronautics and Space Administration
  - National Science Foundation
  - National Weather Service

- International Organizations
  - British Civil Aviation Authority
  - EUROCONTROL
  - French DGAC
  - International Civil Aviation Organization
- Academic Institutions
  - Embry Riddle Aeronautical University
  - Massachusetts Institute of Technology
  - Pennsylvania State University
  - San Jose State University
  - University of Maryland
  - University of Oklahoma
  - University of Quebec at Montreal

- Non-Profit Organizations
  - Advance General Aviation Transport (AGATE) Consortium
  - RTCA

- Airline Industry
  - America West
  - American
  - Continental
  - Delta
  - Northwest
  - Southwest
  - Trans States
  - TWA
  - US Airways
  - United

- Industry and Industry User Groups
  - ALPA
  - ATA
  - Small Aircraft Manufacturers Association (SAMA)
  - AOPA
  - NBAA

Long-Range View

The very essence of the ATS R,E&D program is to maintain a long-term view of the research requirements for the continued safe and efficient operation, maintenance and use of the air transportation system today and to increase system

safety, capacity and productivity. Although the composition of the R,E&D program portfolio will change over time as some efforts come to fruition and transition to relevant F&E or O&M environment, continued investment in ATS R,E&D will ensure that the FAA stays current with the ever increasing demands on the air traffic system. The ATS R,E&D program is an ongoing effort that will have continuing funding expectations at or beyond the current level. A continued investment in the ATS R,E&D will ensure the FAA has an effective risk identification/mitigation strategy for the high-risk areas of the future NAS architecture.

F&E 1F01 Runway Incursion Reduction

GOALS:

Intended Outcomes: With the Runway Incursion Reduction program (RIRP), the FAA intends to develop technologies and other solutions that minimize the chance of injury, death and damage, or loss of property due to runway accidents/incidents within the civil aviation system. In addition, the program will improve safety and reduce the potential for accidents on the airport surface through increased pilot/controller situational awareness.

Agency Outputs:

- Develop low-cost airport surface detection equipment.
- Develop secondary surveillance capabilities for the airport surface.
- Develop a conflict-alerting and data fusion platform.
- Investigate alternative options such as visual aids (lights and signs), education, training, and advisory circulars.

Customer/Stakeholder Involvement: The Air Traffic Requirements Office has been actively involved in developing requirements to meet objectives of reducing runway incursions. Additionally, the FAA Administrator has made Runway Incursion a priority within the Agency. Reducing runway incursions is second on the National Transportation Safety Board's (NTSB) "Most Wanted List" of safety improvements.

Accomplishments: The following R&D projects were accomplished in FY 1999:

- Completed installation of Airport Target Identification System (ATIDS) at DFW.
- Completed installation of surveillance server at DFW.
- Completed initial ATIDS coverage testing at DFW.
- Continued informal evaluation of Airport Surface Detection Equipment Model X (ASDE-X) radars at Milwaukee, WI and Norfolk, VA.
- Completed initial testing of Loop technology system at Long Beach, CA.

R&D Partnerships:

- Memorandum of Agreement (MOA) with NASA for Low-Visibility Landing and Surface Operations (LVLASO) demonstration in Dallas-Ft. Worth.
- Research contracts on airport surface operations in reduced visibility.
- Raytheon (x-band radar).
- Dassault (phased-array radar).
- Sensis (Vehicle Automatic Dependent Surveillance – Broadcast [ADS-B] and ATIDS).
- CACI (safety algorithms).
- General Working Agreement with Volpe National Transportation Systems Center (VNTSC).
- Contract with AOPA Air Safety Foundation.
- Technology transfer.

Runway incursion reduction technologies—including low-cost radar, secondary surveillance systems, conflict alerting systems, and other alternatives with various contractors—are currently being researched. After system evaluation is completed, specifications will be developed for soliciting competitive bids for production of successfully demonstrated systems. Periodic briefings will also be conducted during the R,E&D phase to inform industry of FAA's requirements for runway incursion reduction solutions.

The FAA is currently developing a specification for the production of an ASDE-X system that will include a radar, multilateration system, and surveillance server.

MAJOR ACTIVITIES AND ANTICIPATED FY 2000 ACCOMPLISHMENTS:

Dallas-Ft. Worth

- ASDE-3, Vehicle ADS-B, Loops, Surveillance Fusion Platform (SFP) integration and testing.
- ASDE-X specification development.
- Full system RIRP prototype demonstration.

Low-cost surface detection equipment

- Complete Y2K upgrade for Dassault ASDE-X and continue evaluation.

- Complete processor and Y2K upgrade for Raytheon ASDE-X and continue evaluation.
- Continue testing technology prototypes including low-cost radar, conflict alerting systems, and other potential runway incursion reduction alternatives.

Air Traffic

- Runway Incursion Action Teams.
- Program Implementation Plan (PIP).
- Airport modeling/data reduction/facility testing.
- Human factors studies.
- Tower Simulators.

KEY FY 2001 PRODUCTS AND MILESTONES:

- Full System RIRP prototype demonstration at Dallas-Ft. Worth.
- Extend RIRP system to Dallas-Ft. Worth (DFW) West Side.
- FAA/NASA RIRP/LVLASO demonstration at DFW.
- Loop technology full system evaluation at Long Beach, CA.
- Air traffic activities including regional training, modeling/data reduction/facility testing, human factors initiatives, and industry conferences.

FY 2001 PROGRAM REQUEST:

In FY 2001, funding will provide for:

- The DFW West Side extension.
- Incorporating real-time seamless surface surveillance with NASA cockpit technology.
- Vehicle ADS-B.
- Loop technology.
- Data fusion.
- Conflict alerting.
- Call sign identification.
- Information sharing with air traffic controllers, pilots, and vehicle operators.
- FAA/NASA Runway Incursion/Low-Visibility Surface Operations Demonstration at DFW.
- Implementation of activities consistent with the 1998 Airport Surface Operations Safety Action Plan, including Runway Incursion Action Team (RIAT) meetings.

Surface Automation Research and Development

GOALS:

Intended Outcomes: The FAA intends to improve the level of safety, increase airport capacity, and reduce costs and delays for aircraft operating on the airport surface by developing new automation, communications, and information distribution capabilities. These capabilities will augment operational decision making processes and improve situational awareness of surface operations under all visibility and weather conditions.

The Surface Movement Advisor (SMA) will provide air traffic controllers, airline ramp managers, and airfield operators with unprecedented advisory and information sharing to help minimize congestion and reduce delays on the airport surface. Recipients of this information- sharing will be able to make informed decisions in managing airport surface resources. Specific SMA goals include:

- Facilitate an electronic exchange of flight critical information among airlines, air traffic control personnel, and airport operators.
- Provide dynamic real-time data to help increase efficiency of ground movement operations.
- Predict surface events that impact operational decision making.
- Help achieve at least a 10 percent decrease in taxi-out delays.

This coordination will improve safety by minimizing the risk of collisions and increasing the efficiency of aircraft movements on airport runways and taxiways. It will help meet system capacity needs by reducing constraints/limitations at the top level V delay/operationally impacted airports while improving the automated infrastructure to provide capacity-enhancing technologies and procedures. It will also create capabilities that ensure safe separation while imposing minimum constraints on system users.

Low/zero-visibility tower environment R,E&D will develop augmentations to the air traffic tower environment that can provide an operationally useful, enhanced or synthetic view of the airport surface during periods of low- or zero-visibility. This will lead to improved safety and increased use of airport surface capacity under low or zero visibility conditions, and ensure that the airport surface capacity is adequate to manage the increased aircraft landing rates expected in the future.

Agency Outputs: The surface automation research and development program will produce new tower surface management functions and technologies that will be validated in pre-production prototype systems in an operational tower/airfield environment. Assessments of airport operational effectiveness, performance, and benefits will be included to assist in the investment decision making process. These activities will result in functional packages and specifications that can be transferred for implementation on the appropriate tower automation platform. This program will also result in new air traffic control, airline, and airport operating procedures for managing aircraft on the airport surface.

The low/zero visibility tower environment R,E&D program initiatives will develop prototype systems that provide synthetic views of the airport surface under all restricted visibility conditions. This will lead to the definition of operational requirements, procedures, emerging technologies, and system requirements for continuous operations under all visual conditions.

Customer/Stakeholder Involvement:

- The R,E&D program commits the FAA to increasing airfield safety and reducing runway incursions.
- The surface automation R&D involves the airlines and airport operators through an unprecedented sharing of dynamic, operationally critical information.
- The R,E&D program has involved the customers and stakeholders from concept exploration through development of a prototype system at Atlanta Hartsfield International Airport. Air traffic controllers, airport authority, and aircraft operators have contributed to defining the functional performance of surface automation tools and have participated on the program design and management teams.

Accomplishments:

- Completed SMA concept evaluation and development.
- Installed SMA prototype at Atlanta Hartsfield International Airport (2/96).
- Brought airport/ramp towers on-line (7/96).
- Completed Support Command/National Air Traffic Controllers Association (SUPCOM/NATCA) testing and initial evaluation (9/96).
- Began operational assessment (10/96).
- Completed operational assessment (05/97).
- Completed SMA benefit analysis (10/97).

R&D Partnerships: The R,E&D program is being conducted in close partnership with NASA through the interagency ATM integrated product team (IPT), a joint research and technology development program managed cooperatively by the FAA and NASA. The NASA Ames Research Center is a key participant in the program's R,E&D activities.

Benefits to air traffic operators include an increase in terminal area situational awareness and reduced radio frequency congestion.

MAJOR ACTIVITIES AND ANTICIPATED FY 2000 ACCOMPLISHMENTS:

- Sustained operational SMA prototype at Atlanta Hartsfield International Airport.

KEY FY 2001 PRODUCTS AND MILESTONES:

- Sustain SMA prototype at Atlanta Hartsfield International Airport.

FY 2001 PROGRAM REQUEST:

Sustain SMA prototype at Atlanta Hartsfield International Airport.

Runway Incursion Reduction Product and Activities	FY 2001 Request ($000)	Program Schedule					
		FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY2005
021-250 Runway Incursion Reduction							
Runway Incursion Plan	$4,750						
Update Project Plan		◆	◇	◇	◇	◇	◇
Complete Prototype Testing of Radar Technologies		◆	◇	◇	◇	◇	◇
Phased Array Radar (Norfolk)		◆	◇	◇	◇	◇	◇
Prototyping Testing and Additional Technologies		◆	◇	◇	◇	◇	◇
Data Fusion/ATIDS/ADS-B/Loops (DFW)		◆	◇	◇	◇	◇	◇
Loop Technology (Long Beach)		◆	◇	◇	◇	◇	◇
FAA/NASA Evaluation (DFW)		◆	◇	◇	◇	◇	◇
Secondary Sensors		◆	◇	◇	◇	◇	◇
Select Systems for Full-Scale Validation Testing		◆	◇	◇	◇	◇	◇
Continuous Research on Additional Technologies		◆	◇	◇	◇	◇	◇
Runway Incursion Non-Technical Solutions	$3,200						
Develop Procedures		◆	◇	◇	◇	◇	◇
Develop Educational Process		◆	◇	◇	◇	◇	◇
Develop Training Guidelines		◆	◇	◇	◇	◇	◇
Total Budget Authority	$7,950	**	$7,950	$5,700	$5,700	$5,700	$5,700

Note: Out year numbers are for planning purposes only. Actual funding needs will be determined through the annual budget process.

Budget Authority ($ in Thousands)	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Enacted	FY 2001 Request
Contracts	4,950	5,696	2,269		7,950
Personnel Costs	872	252	899	**	***
Other Costs	178	52	0		***
Total	6,000	6,000	3,168		7,950

** By Congressional direction, budget line item 1F01 was reduced in FY 2000. The allocation of that reduction is currently under review.

*** In the Facilities and Equipment appropriations, personnel and other costs are budgeted in Activity 5, not the program budget line item.

F&E 1F01 System Capacity, Planning and Improvements

GOALS:

Intended Outcomes: The FAA intends to develop an overall strategy to enhance capacity. This includes both terminal and enroute airport and airspace assessment of procedures and capacity-related technologies. It also includes developing a performance measurement system for the air traffic system to measure FAA progress against customer expectations. This strategy coordinates across budgetary lines allowing programs and projects to improve investment decision making and to achieve optimal strategic and operational results.

Initiatives are implemented in aviation system capacity planning to increase the number of aircraft operations per hour, reduce both enroute and terminal airspace delays, reduce controller workload, and increase savings. As a result, the FAA, and the overall aviation community, will experience lower maintenance/operating costs. This program: (1) complies with the congressional mandate to produce airport improvement plans; (2) responds to the aviation industry's high-priority initiatives for increased capacity; (3) responds to the Presidential Commission on Improved Airline Competitiveness recommendations; and (4) complies with the Government Performance and Results Act (GPRA) of 1993 and Executive order on infrastructure investment requirements.

Agency Outputs: To comply with GPRA, ATS has developed four areas of capacity-related outcomes: flexibility, predictability, access, and delay. These outcomes provide guidance and a framework to enable any ATS R,E&D program to successfully increase the value of services and, in parallel, reduce the cost of these services to the public. The capacity program strictly adheres to the guidelines of the following four areas:

Flexibility.

The FAA estimates that each year operators experience a minimum of $558 million in inefficiencies in the terminal and enroute airspace. The capacity program provides models and simulations that assess present shortfalls within the subject airspace. These models and simulations determine the delay, travel time, sector loading, and operating cost effects of all suggested redesign alternatives. Results include:

- The redesign of Las Vegas terminal and enroute arrival procedures.
- New departure routes from Los Angeles International Airport.
- Airspace suggested changes to Phoenix departure procedures.
- New dual arrival procedures into San Francisco.
- Annual savings to the aviation industry at airports and enroute facilities estimated at a minimum of $450 million annually.

Predictability.

Because it can impose capacity restrictions at major airports, weather is the most dominant influence on air transportation. Although many airports are equipped with multiple runways (many converging), their resources become extremely restricted due to associated weather minima. The capacity program establishes criteria to develop and improve simultaneous converging instrument approaches and has achieved the following results:

- Reductions in the approach minima, ensuring an average capacity gain of 30 arrivals per hour.
- Fundamental increases in the predictability of the system.
- Use (anticipated) of the Global Positioning System (GPS).
- Combined savings (estimated) to the air carriers $40 million annually.

Access.

In the capacity program, the outcomes of predictability (the ability to land at a particular airport) and having access to that airport, are often considered the same thing. Work required to accomplish these outcomes, however, is different. Predictability establishes approaches to increase capacity under certain weather conditions. Access models simulate new technologies and procedures to ensure that these technologies are compatible for the airport in question. Examples include:

- Precision Runway Monitor—for closely spaced parallel runways with center lines separated by 3,000 feet (reduced from 4,300 feet).
- Reduced separation of 2.5 nmi on final approach (reduced from 3.0 nmi).
- Dependent staggered approaches to closely spaced parallel runways using 1.5 nmi diagonal separation.
- Offset Approach Course guidance for simultaneous operations at San Francisco, Newark, St. Louis, Cleveland, Seattle and other candidate airports.
- Converging approach standards at Chicago O'Hare, Dulles, and Dallas-Ft. Worth International Airports.

Delay.

The major capacity program emphasis is to minimize the impact of airport and airspace delay on the overall NAS. One primary program focus is responding to near-term, airport-driven capacity issues. By 2008, 21 of the top 29 large hub airports are projected to exceed an average of five minutes of delay per operation. This is cause for concern within the aviation industry. Delay reduction initiatives undertaken to date include:

- The capacity program has completed more than 50 airport enhancement projects.
- The program supports development of an overall capacity strategy that considers airport and technology conduct, measurement, and assessment; and electronic tools development and application to aid in forming that strategy.
- Airfield improvements such as new runways and runway extensions, improved approach procedures, and new facilities and equipment such as the precision runway monitor are being investigated.
- The improvements producing the greatest capacity increases, estimated delay reductions, and delay cost savings, are described and recommended for implementation in the final design plans.
- The top recommendations at any one airport are estimated to save the aviation industry $75–$100 million annually.
- Since 1995, based on recommendations, 20 new runways have been constructed at major airports.
- Efforts are underway to accommodate New Large Aircraft into the operational environment.

The FAA's airport and airspace design programs have the dual objectives of addressing tactical improvements, in response to industry requirement shifts, and facilitating large-scale investment analysis and optimization planning. Securing active cooperation at the local (regional) level, and the high degree of coordination needed among affected facilities and user groups, pose process problems.

Various solutions to these problems have been proposed and simulated. The results have then been compared to make intelligent investment decisions. A detailed example follows:

> Problem: On the Dallas-Ft. Worth Metroplex project, which involved substantial Airports Improvement Program (AIP), F&E, and operational investment, the effects on the system of several airspace structures, including a "do nothing" scenario, were compared.
>
> Solution: Given the industry's plan to expand operations at Dallas-Ft. Worth, the FAA concluded it was best to expand the airport. This meant designing new airspace supported by upgraded navigation and communications capabilities along with entirely new arrival and departure procedures.
>
> Result: This approach enabled the community to construct a new runway and ground infrastructure. It also enabled the industry to schedule growth and capital investment.
>
> Comment: This plan instilled confidence that there would be a return on investment since the revised system could support anticipated demand. The industry and local community, therefore, could commit this expanded service to the public. The cumulative 20-year (1997–2016) estimated aircraft operating cost savings based on the

Dallas-Ft. Worth Metroplex, East Runway, and New West Runway in 2003 is $13 Billion.

Customer/Stakeholder Involvement: Although the FAA directs the entire capacity program, customers and stakeholders play active roles in its success. Airport authorities from all concerned airports, air carrier representatives, aviation interest groups, and FAA regional and local air traffic control personnel are an integral part of every airspace and airport capacity task force/project.

The capacity program annually publishes the Aviation Capacity Enhancement Plan to keep the aviation world informed of progress and advancements in the capacity arena. Members of the international aviation community regularly request this document. Requestors in this country include Congress; scholars and students, who use it for their aviation studies; and aviation groups, who use it to develop congressional budget justifications.

As previously stated in "Goals," the overall capacity program parallels the congressional mandates concerning airport improvement plans and agency performance and results.

Accomplishments: Airport and airspace recommendations and redesign studies have produced a conservatively estimated $1.2 billion in savings to the aviation industry. An accurate estimate is difficult because the improvements, either combined or treated individually, are a direct cause of the constant increase in traffic. The program has recently accomplished the following:

- Prototyped and tested initial system performance measures.
- Completed more than 50 major airport studies—some of which have been updated due to growth. Estimated annual savings $75–$100 million per airport.
- Completed four major terminal/enroute airspace redesigns: (1) Las Vegas approach procedures; (2) Los Angeles terminal procedure and ZLA Sectors; (3) Phoenix departure procedures; and (4) Dual arrival procedures into San Francisco.
- Completed aircraft ground movement analysis studies at Las Vegas and Salt Lake City International Airports.
- Completed Palles Verdes airspace environmental initiative.

The program's achievements reach beyond U.S. airspace. Inquiries about our modeling and design methods and requests for assistance have been received from countries in Asia and Europe (e.g., Frankfurt am Main International Airport, Germany, and the new International airport in Seoul, South Korea).

R&D Partnerships:

- In accordance with the annex of the memorandum of understanding between the FAA and EUROCONTROL, the capacity program has established a joint airspace technologies and initiatives group to modernize international aviation. The intended outcome is to meet compatibility requirements between the United States and the rest of the aviation world in such areas as Free Flight, GPS, the flight management system, the precision runway monitor, and other emerging technologies.
- The FAA will partner with major air carriers and business aviation aircraft in developing financial management systems approaches.
- The FAA will partner with NASA in using performance measures developed by the capacity program for ATS in compliance with the Congressional mandate for GPRA. The FAA will participate in joint computer simulation modeling for TRACON systems including the Center Tracon Automation System (CTAS) and the Standard Terminal Automation Replacement System (STARS).
- NASA Short Haul Civil Tiltrotor simulation of proposed Simultaneous Non-Interfering (SNI) Approach procedure.
- The FAA will partner with aircraft manufacturers Boeing and Airbus, avionics manufacturers, Municipal Airport Authorities, Airports Council International – North America, Air Transport Association, and the Airlines Pilots Association for proposed New Large Aircraft (NLA).
- Wide Area Augmentation System/Local Area Augmentation System (WAAS/LAAS) for Minimum Vectoring Altitude (MVA) and Automatic Dependent Surveillance – Broadcast

(ADS-B) for closely spaced parallel runway analysis for Airports Council International – North America (ACI-NA).

MAJOR ACTIVITIES AND ANTICIPATED FY 2000 ACCOMPLISHMENTS:

- Continuously conducted research to develop, refine, and/or enhance high-level outcome performance metrics that were then integrated into processes supporting GPRA requirements and investment decisionmaking.
- Initiated Offset Approach Course guidance for simultaneous operations at San Francisco.
- Developed new Instrument Flight Rules (IFR) approach and departure concepts and procedures for improving the safety and efficiency of operations at capacity constrained airports.
- Identified the impact and develop proposed solutions to the planned introduction of New Large Aircraft in the NAS.
- Initiated converging approach standards at Chicago O'Hare International Airport.
- Initiated Airport Design Studies at John F. Kennedy, La Guardia, and Portland airports.
- Completed ground analysis at Phoenix Sky Harbor International Airport.
- Initiated redesign of the Phoenix Sky Harbor terminal airspace and the Oakland, Los Angeles, and Albuquerque ARTCCs.
- Initiated efforts to accommodate New Large Aircraft into the operational environment.
- Completed Newark and Tampa Airport Design Studies.
- Continued Airspace review for relocation of the Honolulu Center Radar Approach Control (CERAP).
- Participated in airport design study at Dulles International Airport and Baltimore- Washington International Airport.
- Developed procedural alternatives for increased capacity in Anchorage area.
- Completed experiment on civil tilt rotor operations into Newark.
- Explored 250 knot departure route restriction at Houston.
- Initiated and completed the Aviation Capacity Enhancement (ACE) Plan.
- Initiated NAS integration studies at 11 major airports.

KEY FY 2001 PRODUCTS AND MILESTONES:

- Continue to develop new IFR approach and departure concepts and procedures.
- Initiate offset approach course for simultaneous operations at St. Louis and Newark.
- Continue to develop proposed solutions to integrate New Large Aircraft into the NAS.
- Complete airport design study at JFK, terminal area airspace study at Anchorage, and ground analysis at Phoenix Sky Harbor International Airport.
- Complete redesign of Honolulu CERAP and Phoenix-Tucson tower enroute control procedures within Albuquerque and adjacent ARTCCs.
- Continue analysis of new and/or additional performance measures for the national airspace system.
- Initiate and complete the ACE Plan.
- Initiate airspace analysis for Seattle and NCT/SCT.

FY 2001 PROGRAM REQUEST:

In FY 2001, the program will focus on capacity enhancement at all major airports as well as on terminal and enroute airspace. Primary focus areas are: (1) airports where construction of suggested improvements can be completed within two to three years; and (2) air traffic radar facilities where airspace redesign reduces controller workload and provides the aviation industry with additional flexibility and predictability during flight.

In addition, the program will continue to fine tune air traffic system performance measures. These efforts will concentrate on reducing the cost of service delivery by targeting and coordinating investments across appropriations.

System Capacity, Planning and Improvements	FY 2001 Request ($000)	Program Schedule					
		FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY2005
Aviation System Capacity Planning							
Enhance/Design Plans & Consolidated Ops & Analysis Systems	$1,500						
Aviation Capacity Enhancement Plans (Annual)		◆	◇	◇	◇	◇	◇
Regional/Airport Design Team Plans		◆	◇	◇	◇	◇	◇
Performance Measurement/Government Performance Results Act (GPRA)		◆	◇	◇	◇	◇	◇
Airspace/Airport Analysis	$3,800						
Completed Airspace Redesign of Las Vegas, Salt Lake Terminal and ARTCC, Las Vegas Approach Procedures, Los Angeles Terminal Procedures and 2 Los Angeles Sectors, and San Francisco Arrival Procedures		◆					
Redesign or Analysis of Phoenix, Seattle ARTCC and Albuquerque ARTCC		◆	◇	◇			
Integrate Measures into the Budget Process and GPRA				◇			
Performance Reports for Investment Decisions				◇	◇	◇	◇
Completed Newark, Tampa, and San Diego Airport Design Studies		◆					
Analyze New and/or Additional Performance Metrics for the National Airspace System			◇	◇	◇	◇	◇
Ground Analysis of Phoenix Sky Harbor International Airport		◆	◇				
Completed Anchorage Design Team Project		◆					
Analyze Low Level Routes Between Northern and Southern California					◇	◇	
Perform Ground Analysis For Pittsburgh and Kansas City Airports					◇	◇	
San Francisco Ground Task Force					◇	◇	◇
Develop Simultaneous Offset Instrument Approaches for San Francisco, St. Louis, Newark, Cleveland, and Seattle Airports		◆	◇	◇	◇		
Develop Converging Approach Standards at Chicago O'Hare and Dallas-Fort Worth Airports		◆	◇	◇	◇		
Accommodate New Large Aircraft into the Operational Environment		◆	◇	◇	◇		
Developed New Departure Routes from Los Angeles International Airport		◆					
Develop Design Studies at John F. Kennedy, La Guardia, and Portland Airports		◆	◇	◇			
Redesign Honolulu CERAP and Phoenix-Tucson Tower En Route Control Procedures			◇				
Developed Airport Design Studies at Dulles and Baltimore-Washington International Airports		◆					
EWR Tilt Rotor		◆					
Houston 250 Knot		◆					
Total Budget Authority	$5,300	**	$5,300	$5,300	$5,600	$5,900	$6,200

Note: Out year numbers are for planning purposes only. Actual funding needs will be determined through the annual budget process.

Budget Authority ($ in Thousands)	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Enacted	FY 2001 Request
Contracts	2,392		228		5,300
Personnel Costs	3,419		1,627	**	***
Other Costs	0		0		***
Total	5,811		1,855		5,300

** By Congressional direction, budget line item 1F01 was reduced in FY 2000. The allocation of that reduction is currently under review.

*** In the Facilities and Equipment appropriations, personnel and other costs are budgeted in Activity 5, not the program budget line item.

F&E 1F01 — General Aviation and Vertical Flight Technology Program

GOALS:

Intended Outcomes: The General Aviation and Vertical Flight (GA&VF) technology program supports GA demands for Communications, Navigation, and Surveillance (CNS) technologies through applied research and development. These technologies support cost-effective air traffic services, improve safety, and expand NAS capacity and efficiency — especially where CNS services are not currently available to GA users. GA&VF program products are integral to NAS modernization.

The FAA GA&VF technology program supports research and development across the full spectrum of GA operations. The program's research areas align with the most critical components for GA participation in the NAS-terminal operations: enroute communications and navigation, landing facilities, airmen and controller training, and low-cost avionics.

Vertical flight Terminal Instrument Procedures (TERPS) efforts support the terminal and enroute flight environment. Low-altitude CNS research provides critical data and evaluations for future low-altitude enroute infrastructure to support Free Flight. TERPS capabilities facilitate implementation and use of advanced technology in the cockpit and at the controllers' workstation for GA needs. These efforts are interrelated and support mutual requirements without duplication or added costs.

Agency Outputs: The GA & VF technology program helps generate design criteria, publish advisory circulars and training documents, and provide for collaborative technology integration with the current and future NAS. This program area also provides technical and management expertise to establish highly successful partnerships.

The project creates the following types of products and engages in the following activities related to Rotorcraft IFR Procedures and Infrastructure:

Terminal Airspace

Criteria and design parameters for instrument approaches to hospital, corporate, and business district heliports. This development effort supports TERPS criteria, aircraft and avionics certification standards, Instrument Flight Rules (IFR) Emergency Medical Service (EMS) procedures and training guidance, as well as Minimum Aviation System Performance Standards (MASPS), Minimum Operational Performance Standards (MOPS), and Technical Standard Orders (TSO).

Rotorcraft Air routes

Procedures and test systems designed in an operational environment to work with Global Positioning System (GPS) navigation, surveillance and terrain avoidance technology developed by other projects. Resulting experience and information helps to integrate newer, safer, and more efficient rotorcraft routings into the NAS, including the Gulf of Mexico, and can be useful to other GA systems operating at low altitudes.

Avionics and Cockpit Technology

Avionics, equipment, procedures, and related testing to enable the safe efficient integration of GA aircraft into the NAS. These efforts have become particularly important with the introduction of GPS navigation/landing and surveillance systems, Free Flight and other advanced concepts.

Low Altitude CNS Infrastructure

Route system guidelines, cockpit display guidelines, noise abatement procedures, and terminal and enroute system integration plans for low altitude CNS operations.

Customer/Stakeholder Involvement: The GA program directly supports goals and programs delineated in Challenge 2000, the Aviation Safety Plan, the RTCA Free Flight Action Plan, and NAS architecture development. The program emphasizes the GA&VF community's direct needs related to helicopters and tiltrotors. Specific stakeholders include:

- Helicopter Association International.
- American Helicopter Society.
- National Business Aircraft Association.
- Experimental Aircraft Association.
- General Aviation Manufacturers Association.
- Small Aircraft Manufacturers Association.

- National Association of State Aviation Officials.
- Association of Aeronautical Medical Services.
- National Emergency Medical Services Pilots Association.
- Airborne Law Enforcement Association.

R&D Partnerships: Historically, the GA&VF technology program has maintained a unique R&D collaboration with industry. Partnerships existing or planned for the near future include:

- Experimental Aircraft Association in advanced technology avionics — for single pilot GA aircraft.
- Helicopter manufacturers and user organizations — to focus development of IFR procedures (including approaches) as well as systems and equipment to meet user identified and validated operational needs.

MAJOR ACTIVITIES AND ANTICIPATED FY 2000 ACCOMPLISHMENTS:

- Completed flight test evaluation report in support of helicopter instrument approaches as a function of differential GPS technology equipage. The report will facilitate the development of special differential GPS helicopter precision approaches. (3/00)
- Developed a Strategic plan and operations concept for vertical flight operations using advanced technology. (4/00)
- Developed an operations concept plan to provide enhanced weather data and Flight Information Services to helicopter operations in the Gulf of Mexico as part of the next generation CNS technology (6/00).
- Developed GPS based route criteria for low altitude air route system. (9/00)

KEY FY 2001 PRODUCTS AND MILESTONES:

- Revise airplane and rotorcraft VFR procedures and standards to incorporate new technology (e.g. moving map, terrain data, and cockpit weather information, ADS-B). (7/01)
- Establish standards for FIS data link services for offshore vertical flight operations in the Gulf of Mexico (8/01).
- Develop procedures and demonstration for simultaneous non-interfering operations for emergency response operations and law enforcement. (9/01).

FY 2001 PROGRAM REQUEST:

- Development of improved VFR procedures and standards to take advantage of new technology capabilities.
- Continue research leading to establishing improved low speed GPS precision approach TERPS criteria for vertical flight aircraft operations.
- Develop procedures and standards for vertical flight simultaneous non-interfering VFR and IFR operations in terminal areas.
- Continue research supporting use of advanced avionics (including GPS navigation, dependent surveillance, and cockpit display of traffic and weather information).

General Aviation and Vertical Flight Technology Program Product and Activities	FY 2001 Request ($000)	Program Schedule					
		FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY2005
General Aviation and Vertical Flight							
Developed Augmented Fixed Wing Visual Flight Rules (VFR) Procedures and Technology Applications/Standards (ADS-B, Moving Map, Terrain, Weather)	$160		◇				
Developed Pilot Procedures and Instrumentation for Low Speed Operations	$210		◇				
Developed Augmented Rotorcraft VFR Operational Procedures for Simultaneous Non-Interfering (SNI) VFR Operations	$350						
Law Enforcement Emergency Response			◇				
Standardized Terminal Area Route Criteria			◇				
Technology Applications/Standards			◇				
FAR Part 135 ADS-B Locating Applications	$70		◇				
Business Management	$150		◇				
Salt Lake City Olympics Support	$2,000		◇				
Total Budget Authority	$2,940	**	$2,940	$1,000	$1,200	$1,400	$1,500

Note: Out year numbers are for planning purposes only. Actual funding needs will be determined through the annual budget process.

Budget Authority ($ in Thousands)	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Enacted	FY 2001 Request
Contracts	1,486	0	1,462		2,940
Personnel Costs	925	0	1,440	**	***
Other Costs	189	0	0		***
Total	2,600	0	2,902		2,940

** By Congressional direction, budget line item 1F01 was reduced in FY 2000. The allocation of that reduction is currently under review.

*** In the Facilities and Equipment appropriations, personnel and other costs are budgeted in Activity 5, not the program budget line item.

Safe Flight 21

GOALS:

Intended Outcomes: Safe Flight 21 is a government/industry initiative designed to demonstrate and validate, in a real-world environment, the capabilities of advanced communications, navigation, surveillance, and air traffic procedures associated with Free Flight. The program will be a step in implementing any capabilities that prove to be beneficial. Specifically, Safe Flight 21:

- Enhances safety.
- Increases system capacity and efficiency.
- Maximizes user equipage costs and FAA operational costs.
- Addresses pilot and controller human factors issues.
- Develops and assesses new operational procedures and associated training.
- Streamlines certification processes and procedures.
- Develops a cost-effective avionics and NAS infrastructure.
- Defines a realistic NAS transition path supported by the user community.

Agency Outputs: Safe Flight 21 is essential to the risk mitigation and evolution of the NAS. The program will address the risks and challenges of fielding advanced communications, surveillance, and navigation systems, such as Automatic Dependent Surveillance - Broadcast (ADS-B), Cockpit Display of Traffic Information (CDTI), Flight Information Services (FIS), and the Traffic Information Service – Broadcast (TIS-B).

Under FAA leadership in coordination with RTCA, user participants have committed to spending resources to accomplish the Safe Flight 21 objective:

> "To show that integrated Communication Navigation and Surveillance (CNS) technological capabilities can provide functional enhancements that will produce operational benefits and sufficient cost/benefit to justify implementation. FAA policies and decisions should be based upon the ongoing results of this program."

This objective will be achieved through the following:

- Evaluating the three ADS-B links (1090MHz, UAT, and VDL Mode 4)
- Conducting operational evaluations of the following nine operational enhancements identified by RTCA:
  - FIS for Special Use Airspace (SUA) status, weather, windshear, Notices To Airmen (NOTAM), and Pilot Reports (PIREP).
  - Cost-effective Controlled Flight Into Terrain (CFIT) avoidance through graphical position display.
  - Improved terminal operations in low-visibility conditions.
  - Enhanced see-and-avoid.
  - Enhanced operations for enroute air-to-air communications.
  - Improved surface navigation.
  - Enhanced airport surface surveillance for controllers.
  - ADS-B for surveillance in non-radar airspace.
  - Establishing ADS-B-based separation standards.

Customer/Stakeholder Involvement: The Safe Flight 21 resulted from inputs that the FAA Administrator requested from the RTCA Select Committee on Free Flight Implementation. The Safe Flight 21 program is a jointly developed program that is strongly endorsed by the RTCA Free Flight Steering Committee. The Safe Flight 21 steering committee includes RTCA Select Committee representatives from the FAA, the Aircraft Owners and Pilots Association (AOPA), the Airline Pilots Association (ALPA), the National Air Traffic Control Association (ATCA), the Cargo Airline Association (CAA), the MITRE Corporation, and U.S. Airways.

Accomplishments:

- Established the Safe Flight 21 program office.
- Obtained approval for FY 1999-2000 funding to support the CAA work and the Alaska Capstone program.

- Provided details for risk mitigation activities, site locations, number of aircraft required, cost, and schedule.
- Completed evaluation of ADS-B enhanced visual approaches using ADS-B only.
- Completed evaluation of enhanced visual acquisition for see and avoid using ADS-B only.

R&D Partnerships: The Safe Flight 21 program is based on the principle that government and industry will share in the development of a global air transportation system as we move into the Free Flight era.

The FAA will partner the aviation industry in supporting Safe Flight 21. This will allow the FAA to build on ongoing industry initiatives. It will also allow industry and the FAA to fund avionics and ground systems. Safe Flight 21 will build on the Alaska and CAA activities by addressing:

- ADS-B technology issues.
- Cockpit human factors issues.
- Use of FIS to receive weather and other information.
- An integrated cockpit display of terrain, traffic, and weather information.
- Work with the CAA is being addressed by a Cooperative Research and Development Agreement (CRDA).
- Organizations representing controllers and commercial and general aviation pilots are included in Safe Flight 21 planning and in evaluation of the operational enhancements and data link alternatives.

MAJOR ACTIVITIES AND ANTICIPATED FY 2000 ACCOMPLISHMENTS:

The FAA anticipates to accomplish the following FY 2000 tasks toward implementing Safe Flight 21 program in the Ohio Valley in preparation for CAA ADS-B evaluation work and the Alaska Capstone program:

- Procured and installed ADS-B ground stations in Ohio River Valley and in the YK delta region in Alaska.
- Procured and installed FIS and the Automated Weather Observation System (AWOS) in Alaska.
- Procured and installed avionics in FAA and Alaska aircraft (CAA provides avionics in CAA aircraft).
- Procured and installed ADS-B surface surveillance equipment.
- Procured and installed terminal automation equipment for ADS-B/radar fusion evaluation.
- Continued operational evaluation of the nine operational enhancements.
- Initiated procedures development.
- Evaluated the three ADS-B links and submitted link status report.
- Required avionics manufacturers to submit applications for selected ADS-B air-to-air applications.
- Completed evaluations of:
- Enhanced visual approaches
- Final approach spacing
- Runway and final approach occupancy awareness
- Presentation of ADS-B targets to controllers
- ADS-B enhancement of terminal surveillance
- Presentation of today's FIS-B products in the cockpit
- Low-cost terrain situational awareness
- Separation of aircraft in non-radar airspace using ADS-B

KEY FY 2001 PRODUCTS AND MILESTONES:

Avionics and ground systems

- Complete initiated procurement activities, as needed. (Focus on end-to-end evaluations.)

Engineering and operational evaluation

- Continue the Safe Flight 21 program plan.
- Continue operational evaluation for the nine operational enhancements.
- Continue enhanced visual approaches using ADS-B and TIS-B.
- Continue final approach spacing using ADS-B and TIS-B.
- Continue enhanced see and avoid using ADS-B and TIS-B.

- Continue runway and final occupancy awareness using ADS-B and TIS-B.
- Continue ADS-B surface surveillance at airports without ASDE.
- Extend FIS-B products to the cockpit.
- Increase access to terrain-constrained low altitude airspace.
- Continue procedure development and certification tasks.
- Make globally harmonized ADS-B link decision.

FY 2001 PROGRAM REQUEST:

FY 2001 funding completes procurement of avionics and ground systems necessary for the operational evaluations. Funding also provides for operational evaluation, procedures development, and certification tasks.F&D 1F01 — Operations Concept Validation

GOALS:

The RTCA Free Flight Steering Committee, the FAA's R,E&D Advisory Committee, the White House Commission on Aviation Safety and Security, and numerous other members of the aviation community have called for development and validation of a Concept of Operations for Modernization. This concept is to be used as the driver and the integration guidance for the transition from the current rigid procedures and outdated failing infrastructure to a Free Flight environment. The RTCA Task Force 3 provided the modernized NAS capability descriptions sought by the user community. The validated operational concept describes how each part of the NAS, both ground and air, interacts to provide the capabilities while transitioning to a new infrastructure involving planners, pilots, service providers, and systems.

Safe Flight 21 (Capstone Initiative/Ohio Valley) Product and Activities	FY 2001 Request ($000)	Program Schedule					
		FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY2005
Safe Flight 21 (Capstone Initiative/Ohio Valley)							
Operational Enhancements	$23,500						
Provide Weather and Other Information to the Cockpit		◆	◇	◇			
Provide Affordable Means to Reduce Controlled Flight Into Terrain (CFIT)		◆	◇	◇			
Improve Capability for Approaches in Low Visibility Conditions		◆	◇	◇			
Enhance Capability to See and Avoid Adjacent Traffic		◆	◇	◇			
Enhance Capability to Delegate Aircraft Separation Authority to the Pilot			◇	◇	◇	◇	◇
Improve Capability of Pilots to Navigate Airport Taxiways		◆	◇	◇	◇		
Enhance Capability for Controllers to Manage Aircraft and Vehicular Traffic on Airport Surface		◆		◇	◇	◇	◇
Provide Surveillance Coverage in Non-Radar Airspace		◆		◇	◇	◇	
Provide Improved Separation Standards		◆					
Data Link Evaluation	$1,500						
Program Management and Support		◆	◇		◇		◇
Flight Information Services Available (including Graphical Weather		◆	◇				◇
ADS-B Surveillance and Separation Services Available		◆		◇	◇	◇	◇
Micro-EARTS/ADS-B Modification Complete		◆		◇			
Total Budget Authority	$25,000	$16,000	$25,000	$25,000	$20,000	$15,000	$15,000

Note: Out year numbers are for planning purposes only. Actual funding needs will be determined through the annual budget process.

Budget Authority ($ in Thousands)	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Enacted	FY 2001 Request
Contracts				16,000	25,000
Personnel Costs			****		***
Other Costs					***
Total				16,000	25,000

*** In the Facilities and Equipment appropriations, personnel and other costs are budgeted in Activity 5, not the program budget line item.

**** The FY99 Facilities and Equipment appropriation allocated $11M for the Alaska Capstone project and $5 for the Ohio Valley project. In FY 2000 Safe Flight 21 was Funded as F&E Budget Activity 1.

F&D 1F01 — Operations Concept Validation

GOALS:

Agency Outputs: The agency provides:

- A well-defined and well-understood "validated" operational concept based on system modeling and simulation.
- Validated, integrated, configuration managed requirements for the subsystems of the new target system to provide a coherent, comprehensive framework to guide associated research and development activities (e.g., specific requirements for Automatic Dependent Surveillance Broadcast (ADS-B) capabilities, Surface Management capabilities, Advanced Concept Probe).
- Top-level designs for the major new ATM capabilities and subsystems associated with the operational concept (e.g., the ground-based and airborne information infrastructures required for modernization and the design of a capability to dynamically tailor an air traffic controller's airspace responsibility to more efficiently accommodate traffic demand).
- A system-level safety assessment of the operational concept and associated new capabilities.
- A risk-mitigation plan to guide development activities for new capabilities.
- A human factors validation plan that provides a comprehensive roadmap of activities to ensure that new functionality will be operationally acceptable to flight crews and controllers.

Customer/Stakeholder Involvement: The RTCA Select Committee for Free Flight Implementation cooperates in operational concept development and validation. The FAA has conducted a detailed survey of the major stakeholders to obtain their ranking of future concept sub-elements to support modernization. This level of stakeholder participation — essential for validating the concept for a modern NAS based on a shared, integrated infrastructure — ensures that the concept fully reflects user community requirements.

Accomplishments: The vision for the modern NAS has been developed and published in the *Government/Industry Operational Concept for Free Flight* (RTCA, August 1997) and *A Concept of Operations for the NAS Airspace System in 2005* (Air Traffic Services, September 1997). These documents have provided guidance to the development of the NAS Architecture Version 4.0. Additional details appear in the appendices to this document.

Starting in FY 1999, activities initiated included validation of concepts and associated top-level designs, risk-mitigation planning, and coordination of a validation plan with the human factors activity. These activities include:

Operational concept development

- Developed a detailed framework for individual service enhancement and domains to support the development of system level requirements for modernization.
- Developed a NAS performance model for evaluating the impact of proposed concepts on operational performance.
- Conducted an analysis of current separation procedures as the first step in developing a concept for separation normalization to leverage increased technical performance of NAS systems to meet increasing demand capacity imbalances.

Concept validation

- Conducted a comparison of U.S. Eastern Triangle operations to European core airspace.
- Developed the capability for fast-time analysis of new concepts such as multi-sector planning and dynamic resectorization.

Concept system design

- Conducted an analysis of the effects of dynamic boundaries on operational and controller performance as a step in the development of dynamic sectorization to support increased route flexibility in the face of increasing demand.

R&D Partnerships: This work directly relates to the FAA/NASA Memorandum of Understanding (MOU) on ATM research and development. Work under this program is coordinated through the joint Integrated Product Team Plan to ensure

NASA's efforts complement and are integrated into the NAS Operational Concept. NASA contributes to the development and validation of flight deck concepts and in the far-term ATM system development.

The concept development and concept validation effort is also coordinated with the European community via agreements with EUROCONTROL. This effort ensures that unique solutions/transitions are not developed in different quadrants of the globe, which would impose an undue burden on U.S. carriers, manufacturers, and other participants in the global airspace system.

MAJOR ACTIVITIES AND ANTICIPATED FY 2000 ACCOMPLISHMENTS:

Operational concept development

- Developed detailed concepts for individual service enhancement and domains to support the development of system level requirements for modernization (in particular, to support development of a concept of use for integrated Decision Support Tools for the 03 - 05 timeframe).
- Completed development of quantitative measures and goals for midterm concept capabilities.
- Developed task assignments and information performance requirements for changes to separation assurance based on new roles and technology.

Concept validation

- Developed test-bed for modernization.
- Performed operational analysis, including fast- time simulation.
- Conducted joint FAA/NASA/user concept validation activities, including human-in-the-loop simulations.

Concept system design

- Conducted analysis of enroute sectorization strategies to support the midterm design for the Eastern Triangle.

KEY FY 2001 PRODUCTS AND MILESTONES:

Operational concept development

- Develop detailed concepts for Flight Intent.
- Develop detailed concepts for Information Management of airspace resources to facilitate improved flight planning and impact assessment.
- Develop concept of use for integrated surveillance navigation capabilities for 04-06 timeframe.

Concept validation

- Develop test-bed for modernization.
- Perform airspace assessment of gridded airspace uniform ultra-highs sectors, ultra-high centers.
- Conduct joint FAA/NASA/user concept validation activities, including human-in-the-loop simulations.
- Complete development of information flow model to translate concepts into interface requirements.

Concept system design

- Conduct close loop modeling of changes in Airspace/Airports and user demand.

FY 2001 PROGRAM REQUEST:

The FY 2001 request expands the initial operational concept validation efforts to the point where detailed information and performance requirements will be established for several of the major modernization initiatives, including the information requirements for integrated decision support tools and the Host software reengineering activities. Human factors research is expected to establish the type, update rate, and display requirements. The facilities for human-in–the-loop will be upgraded to provide a fully configurable test-bed for information performance and requirements analysis. This capability will be used to improve analysis of future controller team configurations to meet traffic growth and evaluate a horizontal versus vertical partitioning of NAS airspace.

Leveraging work is being conducted at NASA Langley for safety assessments, the methodology for safety and reliability assessment for the joint air-ground infrastructure that will be used to evaluate reliability and safety performance of future concepts.

Also leveraging work is being performed by: (1) Eurocontrol on the European EATMS Concept

and the associated ATM 2000+ strategy, and (2) the FAA in support of the International Civil Aviation Organization (ICAO) Air Traffic Management Concept Panel.

Operations Concept Validation Product and Activities	FY 2001 Request ($000)	Program Schedule					
		FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY2005
Operations Concept Validation							
Operational Concept Development	$500						
Develop Detailed Concepts for Flight Intent		◆	◇				
Develop Detailed Concepts for Information Management of Airspace Resources to Facilitate Improved Flight Planning and Impact Assessment		◆	◇				◇
Develop Concept of Use for Integrated Surveillance Navigation Capabilities for 04 - 06 Timeframe		◆	◇		◇	◇	◇
Concept Validation	$400						
Develop Testbed for Modernization		◆	◇	◇	◇	◇	◇
Perform Airspace Assessment of Gridded Airspace Uniform Ultra-High Sectors, Ultra-High Centers		◆	◇	◇	◇	◇	◇
Conduct Joint FAA/NASA/User Concept Validation Activities, Including Human-in-the-Loop Simulations		◆	◇	◇	◇	◇	◇
Complete Development of Information Flow Model to Translate Concepts into Interface Requirements		◆	◇	◇	◇	◇	◇
Aviation Support Laboratory (Aircraft)	$510						
Conduct Closed-Loop Modeling of Changes in Airspace/ Airports and User Demand		◆	◇		◇	◇	◇
Aviation Support Laboratory (Aircraft)	$2910						
Total Budget Authority	$4,320	**	$4,320	$1,500	$2,600	$2,700	$2,700

Note: Out year numbers are for planning purposes only. Actual funding needs will be determined through the annual budget process.

Budget Authority ($ in Thousands)	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Enacted	FY 2001 Request
Contracts	0	0	3,412		4,320
Personnel Costs	0	0	3,406	**	***
Other Costs	0	0	0		***
Total	0	0	6,818		4,320

** By Congressional direction, budget line item 1F01 was reduced in FY 2000. The allocation of that reduction is currently under review.

*** In the Facilities and Equipment appropriations, personnel and other costs are budgeted in Activity 5, not the program budget line item.

F&E 1F01 Software Engineering R&D

GOALS:

Intended Outcomes: The FAA intends to improve NAS and avionics safety and reduce NAS and avionics acquisition, development, and maintenance costs by developing and implementing improved software processes and procedures. These actions will directly benefit passengers (as well as all elements of air transportation) and greatly contribute to a safe, secure, and efficient NAS.

The FAA Software Engineering Resource Center (SERC), established in June 1998, is a focal point for research on FAA software-intensive systems. SERC is an FAA-wide resource that will address strategic software technology problems impacting the mission performance and enhancement of FAA in-house software/systems engineering competencies. The primary SERC facilities have been established at the William J. Hughes Technical Center and at FAA headquarters. Remote tie-ins with other facilities are also planned (e.g., at other research sites such as NASA and the EUROCONTROL Experimental Center).

Agency Outputs: The principal products of SERC efforts will include a series of standards, guidelines, models, and "evolvable" prototypes. They will demonstrate, validate, and verify the safety properties, performance, and other critical attributes of anticipated new NAS technologies. SERC also will evaluate and validate improved software processes, methods, and engineering tools that enhance architecture and systems, as well as engineering, testing, and certification functions for the life cycle of NAS systems software. Finally, SERC will bring together recognized experts and FAA personnel to solve problems related to the Commercial Off-The-Shelf/Nondevelopmental Item (COTS/NDI), and the next generation architecture. These activities will transfer skills to and increase the technical competency of the FAA workforce.

Following are specific focus and outcomes of SERC applied research work:

Software certification research.

- Processes for certifying software of safety-critical airborne and ground-based systems within the NAS. Current certification processes require a long leadtime and are costly. Resulting delays affect the rate at which aircraft can be equipped with modern, affordable avionics and are a significant contributor to the long leadtime required for NAS modernization. This research is exploring promising techniques for streamlining the certification process without affecting levels of safety.
- Processes for ensuring end-to-end safety and certification of integrated air and ground systems within the NAS. Air and ground segments are becoming more integrated within the NAS through new services such as data link. The current practice of separately certifying NAS airborne and ground components can no longer be relied upon as the sole means to ensure safety of the integrated air-ground system. This research is investigating and will validate different approaches for performing end-to-end safety assessments and certification of the integrated air-ground systems.

This research will produce a series of guidelines and processes for improving certification of avionics and ground systems. Specific recommendations will also be provided to the appropriate RTCA committees that develop standards and guidelines for certification of avionics systems.

NAS architecture research.

- Evaluation and prototyping of high-integrity, safety-critical architectures. The emphasis is to find better and cheaper ways to ensure that NAS hardware and software are safe, secure, and efficient in the face of challenges from bad code, security breaches, and the like.
- Architecture definition and description. This research is investigating unified approaches to formal architecture definition and description for cost-effective evaluation and comparison of competing candidate architectures for acquisition.
- Analytical and simulation architecture models for the NAS. This research is investigating the operational effects of optimized constraints, including cost and performance, before committing resources to NAS systems implementation and deployment.

- The specific architecture research outputs will be guidelines and standards for defining, representing, and designing high-integrity architectures for the NAS; and, executable and reusable architecture models and simulations that can be extended or tailored to support domain-specific engineering and product acquisitions for the NAS.

Research on applying COTS/NDI within the NAS ground systems and avionics.

- COTS/NDI software assurance research. This research directly supports the Flight Controls and Digital Avionics Systems by investigating conditions that allow COTS software products to be certified to a given currently-defined level of safety. It will help establish selection criteria and evaluation guidelines for ongoing work in Information Security Product Evaluation and a number of other related areas, such as NAS Infrastructure. The research also will identify and evaluate techniques for reducing the cost and time needed to ensure that COTS/NDI software, or systems containing COTS/NDI software, are safe and function as required.
- Evaluation and prototyping of systems and software engineering processes and methods for use in COTS-intensive systems. This research will identify and evaluate more effective practices for use in software requirements definition, software/systems analysis and design, and testing that are appropriate for safety-related systems using COTS/NDI software. It will include investigating different methodologies to quantify, characterize, and guard against the risk of accidentally activating unintended COTS functionality/responses for a given system and environment.
- Software estimation models for COTS-intensive systems. Research is seeking to identify/develop better ways of estimating and predicting the life cycle costs of COTS-intensive systems. This study will include consideration of the complex interactions of major cost and schedule drivers that relate to the evaluation, interfacing, integration, product refreshment, and maintenance of COTS.

This research will produce a set of evaluation criteria and guidelines for COTS software proposed for use in safety-related aviation systems. It will also establish the processes and technical methods required to evaluate COTS/NDI-based systems prior to contract awards and ensure that use of COTS/NDI software will not compromise aviation system safety.

Customer/Stakeholder Involvement: The goal of streamlining the software aspects of certification is to assess cost and schedule drivers for certifying both avionics and ground systems software, and to prototype solutions that may reduce cost and schedules. This supports objectives of the Office of the Associate Administrator for Research and Acquisitions (ARA) and the Office of the Associate Administrator for Regulation and Certification (AVR).

Recommendation R-14 of the "Report of the Challenge 2000 Subcommittee of the FAA R,E&D Advisory Committee for the Administrator" reads, in part:

> "The FAA should conduct an in-depth analysis of processes within the FAA which are affected by COTS/NDI technologies. . . . 5. Identify new methods to test and validate safety-critical systems that are not dependent on source code analysis. 6/7. Investigate ways to reduce cost and time to (re)establish high confidence in a system. . . 18. Promote software technology and process improvement techniques. . . "

The COTS/NDI software assurance research work is directed toward answering the recommendations of this Subcommittee and also addresses concerns and recommendations contained in the *COTS/NDI in Safety-Critical System* report. This research also supports *Action Plan 5: Validation and Certification Methodology* of the FAA/EUROCONTROL R&D Committee agreements.

The *Subcommittee Report of the NAS ATM R&D Panel to R,E&D Advisory Committee* addresses the entire contents of its section 4.0 to Software Engineering Research and Development. It concludes with a number of critical recommendations concerning the need to initiate research in (1) certification of ground as well as air systems involving critical software; (2) systems/software complexity; (3) various software architectural issues such as reuse and reliability; and (4) soft-

ware/computer security. This is all captured within several sections, beginning with the Major Recommendation 4.2.1.a #2, "The FAA should establish a Software Engineering Laboratory under the direction of the Chief Scientist for Software Engineering that performs as a center of excellence." A major purpose of this research initiative is to address the concerns and identified weaknesses noted by the Subcommittee.

Accomplishments:

Software certification research

Initiated a Streamlining Software Aspects of Certification (SSAC) program to focus on identifying cost/schedule/quality issues in the certification of ground-based systems software components.

NAS architecture research

Funded studies to develop a business case for consolidating projects requiring computing resources in order to reduce acquisition, operations and maintenance costs. ("Enterprise view" as opposed to "stovepipe/project specific" approach).

Developed a proposal to leverage investments in Enroute Sustainment projects to include requirements supporting the NAS 4.0 Communications infrastructure. (Cost and People resource savings).

Research on applying COTS/NDI within the NAS ground systems and avionics

Completed development of a Constructive COTS Cost Estimation model (COCOTS) and collected data on 18 projects to begin validation and tuning effort.

NAS Implementation/Supportability Research

Completed NAS adaptation process improvement (API) study. This resulted in initiation of Summary of Mission Analysis Findings for the National Airspace System Resources (NASR) System.

R&D Partnerships:

- Constructive COTS Cost Model – USC, SMI
- COTS Guidelines - SEI
- Adaptation Process Improvement – Boston University
- Evolutionary Spiral Process - SPC
- NAS Architecture - Massachusetts Institute of Technology

Partnership agreements are under discussion with EUROCONTROL, NASA, DOD, NIST, and others.

MAJOR ACTIVITIES AND ANTICIPATED FY 2000 ACCOMPLISHMENTS:

Software certification research

Continued to maintain Communication, Navigation, and Surveillance/Air Traffic Management (CNS/ATM) Guidelines to ensure consistency with RTCA-SC-190, CNS/ATM subgroup.

Research on applying COTS/NDI within the NAS ground systems and avionics

- Established a Constructive COTS Cost Estimation model – Pilot model on 2 FAA projects. This small FAA organizational entity will provide SW cost estimating services as a corporate asset to all of FAA.
- Developed guidelines for test & evaluation of COTS-intensive systems.
- Supported development of COTS life cycle mgmt plans and life-cycle issues, including the Standard Terminal Automation Replacement System (STARS) program and the Display System Replacement (DSR) program.
- Conducted studies and developed prototype applications to improve efficiency of accomplishing NAS Adaptation Services.

NAS architecture research

Funded research studies to develop business cases for consolidation of projects requiring computing resources to reduce acquisition, operations and maintenance costs. (Enterprise view vs. stovepipe/project specific)

KEY FY 2001 PRODUCTS AND MILESTONES:

During FY 2001, the COCOTS model, initial guidelines and prototypes will be available for preliminary use and test. The API Electronic Access to Aeronautical information prototype products will be made available for field use and feedback. The SERC will act as a virtual and physical facility to coordinate development and testing of these software engineering research products.

Links will be established with remote researchers and research sites.

FY 2001 PROGRAM REQUEST:

The software engineering research programs will build upon prior related activities conducted by the SERC and will continue to leverage resources throughout the United States, particularly those of aviation-related programs already underway at several universities. Specific work will be focused on advanced software architecture and technology applications for specific NAS Programs, and on continued end-to-end assurance of safety critical software systems.

Software Engineering R&D Product and Activities	FY 2001 Request ($000)	Program Schedule					
		FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY2005
Software Engineering							
Constructive Commercial Off-the-Shelf (COTS) Cost Estimation Model Development and Pilot Use	$270	◆	◇	◇			
COTS/Non-Destructive Inspection (NDI) Application Research	$50		◇	◇	◇		
NAS Adaptation Services Process Improvement and Prototyping	$300	◆	◇	◇	◇		
NAS Architecture Research	$120	◆	◇	◇	◇	◇	◇
Software Certification Research	$200	◆	◇	◇	◇	◇	
Total Budget Authority	$940	**	$940	$1,000	$1,000	$1,000	$1,100

Note: Out year numbers are for planning purposes only. Actual funding needs will be determined through the annual budget process.

Budget Authority ($ in Thousands)	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Enacted	FY 2001 Request
Contracts	0	0	462		940
Personnel Costs	0	0	538	**	***
Other Costs	0	0	0		***
Total	0	0	1,000		940

** By Congressional direction, budget line item 1F01 was reduced in FY 2000. The allocation of that reduction is currently under review.

*** In the Facilities and Equipment appropriations, personnel and other costs are budgeted in Activity 5, not the program budget line item.

F&E 1F01 — Communications

GOALS:

Intended Outcomes: The FAA intends to increase safety, decrease delays, increase system flexibility and predictability, and increase user access to NAS data base sources by:

- Implementing Decision Support System Services (DSSS) that integrate airborne flight management system capabilities with ground-based decision support automation using aeronautical data link.
- Integrating existing and planned decision support tools with Controller Pilot Data Link Communications (CPDLC) capabilities.
- Enabling increases in system flexibility by using data link services to derive, negotiate, and/or update flight plans both before and during flight.

These improvements also reduce/redistribute air traffic controller workload, increase situational awareness, and alleviate voice traffic congestion.

Providing data link services facilitates the transition from air traffic control to air traffic management and supports the evolution toward a Free Flight environment as envisioned in the RTCA Task Force 3 report and the Free Flight Action Plan.

From its onset, implementation of CPDLC will free-up time controllers had previously spent communicating with aircraft by shifting this task to other members of the controller team. The controllers will then be better able to manage their airspace through use of decision-support tools. The next step is to integrate these tools with the CPDLC capability, thus maximizing the efficiency of both systems.

DSSS will later use existing but not-yet-applied data link applications, in addition to CPDLC, to integrate flight deck automation with ground-based systems and expand on the capabilities just described. Other promising applications still must be developed in conjunction with processes the International Civil Aviation Organization (ICAO) requires for the creation of standards.

Agency Outputs: The FAA provides cost-benefit analyses for DSSS, integrating ground tools and flight deck automation with data link capabilities. Standards and guidance material for DSSS provide technical characteristics and approval guidelines for operational use and training. RTCA standards provide service descriptions, implementation planning, and operational guidance for data link systems. FAA advisory circulars and the Aeronautical Information Manual provide certification guidance for installation and operational use/application. This program develops technical and operational information, including human factors criteria, to support these products.

Customer/Stakeholder Involvement:

Free Flight: The integration of ATM DSSS with controller, pilot, and Airline Operations Center (AOC) facilities systems via digital data link provides enhanced capabilities for trajectory prediction, in-flight planning, and rerouting. ATM DSSS alternatives include Center Tracon Automation System (CTAS) automated enroute air traffic control technologies. Use of these alternatives will reduce the number of current procedural restrictions in the NAS, one of the primary goals of the Free Flight initiative. The development and implementation of FIS/weather products in the cockpit are additional Free Flight goals.

RTCA: Special Committee 194, ATM Data Link Implementation, is responsible for developing consensus implementation plans, principles of operation, operational service description and human factors guidance for data link systems. The Free Flight Steering Committee has recognized this committee as the "keepers" of industry consensus data link plans.

ICAO: The International Civil Aviation Organization leads and participates in the following panels:

- The Automatic Dependent Surveillance Panel—focuses on automated air- ground data exchange.
- The Aeronautical Telecommunication Network Panel—focuses on requirements for a globally interoperable digital data communications network.
- The Aeronautical Mobile Communications Panel—focuses on satellite-based safety services for data and voice, including standards

development for high and very high frequency digital communications.

Aviation Safety Plan: ADL-related initiatives include:

- Initiative 4.2.6—completes the definition of data link systems to support communications, navigation, and surveillance operations.
- Initiative 4.2.7—establishes two-way data link capability throughout domestic enroute and terminal airspace.

Accomplishments: The FMS/ATM Next Generation (FANG) Operational Concept has been published. It identifies a preliminary set of services, associated potential benefits, and required functional capabilities of an integrated flight management system/air traffic management/aeronautical operational control system. RTCA SC-194 has integrated the efforts of FAA, NASA, and industry to detail the implementation requirements for FMS-ATM-AOC services enabled by addressed data link.

Terminal Weather Information for Pilots (TWIP) is currently available at all Terminal Doppler Weather Radar locations through the ARINC Airborne Collision Avoidance Radar System (ACARS) vendor data link service.

Predeparture Clearance (PDC) and Digital-Automated Terminal Information Service (D-ATIS) is currently available through the Tower Data Link System (TDLS) at 57 TDLS locations. These services are also provided through the ARINC ACARS vendor data link service.

TIS is being deployed at all operational terminal Mode S locations. This service provides cockpit presentations of aircraft traffic to client aircraft based on terminal radar surveillance.

R&D Partnerships: The FAA is coordinating development of NAS improvements, including data link applications, with NASA. An interagency Integrated Product Team, formed between the FAA and NASA, develops future ATM systems. FAA and NASA DSSS-related efforts are coordinated through that mechanism.

MAJOR ACTIVITIES AND ANTICIPATED FY 2000 ACCOMPLISHMENTS:

- Completed Joint FAA/NASA En Route Data Exchange flight test, validating the downlink of aircraft state and intent parameters to decision support tools.
- Established required initial data link capabilities for En Route Aeronautical Telecommunications Network Decision Support Tool.

KEY FY 2001 PRODUCTS AND MILESTONES:

- Establish the RTCA DO-Integration, *Implementation Requirements for FMS-ATM-AOC Integrated Services using addressed data link.*
- Perform the operational viability, technical feasibility, and benefits analyses for individual integrated services.

FY 2001 PROGRAM REQUEST:

Aeronautical Data Link works collaboratively with FAA product teams, including enroute, terminal, air traffic management, interfacility telecommunications, and weather to ensure the successful integration of data link services into the NAS.

Decision support system data link enhancement identification and development allows the benefits of advanced ATM automation tools to be fully realized.

Ground simulations and flight evaluations are conducted using the facilities and resources at the William J. Hughes Technical Center and other facilities, including those at the MITRE Center for Advanced Aviation System Development (CAASD), and NASA. These tests identify data link product and system architecture specifications and operational guidance issues to be addressed in the drafting of implementation standards (e.g., MOPS, MASPS), operational guidance documents (advisory circulars), and system architecture strategies.

Communications Product and Activities	FY 2001 Request ($000)	Program Schedule					
		FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY2005
Aeronautical Data Link (ADL) Applications							
Design Support System Services (DSSS)	$2,620						
Begin Validation Efforts for DSSS		◆	◇	◇	◇		
Develop FAA/Industry Consensus for DSSS							
Simulation/Modeling of Proposed DSSS							
Flight Trials/Experiments							
Initial Benefits Analyses							
Initial Acquisition Management System (AMS) Documentation for DSSS							
Develop Procedures/Identify Standards Requirements	$200						
Cost/Benefit Analysis (CBA) for Identified DSSS			◇	◇	◇	◇	◇
Initial DSSS						◇	◇
Total Budget Authority	$2,820	**	$2,820	$3,000	$3,600	$3,200	$2,900

Note: Out year numbers are for planning purposes only. Actual funding needs will be determined through the annual budget process.

Budget Authority ($ in Thousands)	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Enacted	FY 2001 Request
Contracts	1,054	4,706	1,174		2,820
Personnel Costs	4,105	0	4,695	**	***
Other Costs	841	0	0		***
Total	6,000	4,706	5,869		2,820

** By Congressional direction, budget line item 1F01 was reduced in FY 2000. The allocation of that reduction is currently under review.

*** In the Facilities and Equipment appropriations, personnel and other costs are budgeted in Activity 5, not the program budget line item.

F&E 1F01 — Navigation

GOALS:

Intended Outcomes: The FAA intends to provide time efficiencies and cost savings through satellite-based navigation implementation. This technology allows direct point-to-point navigation, optimum routing, and other capacity improvements. These efficiencies and savings—realized by the airlines, the traveling public, and the FAA—include:

- Increased air traffic control efficiencies and NAS capacity through an airway system that is restructured to accommodate direct routings between airports as well as reduced separation standards.
- Reduced fuel cost to airlines and reduced travel time to the public through use of more economical air routes.
- Reduced FAA operating costs through the decommissioning of existing ground-based navigation equipment.
- Simplified Global Positioning System (GPS) augmentation infrastructure through introduction of wide area and local area interoperability that provides satellite navigation services at a reduced cost.

Agency Outputs:

The FAA uses the National Satellite Test Bed (NSTB) as the foundation for all current research and development activities associated with implementing the Wide Area Augmentation System (WAAS). The NSTB is essential to the development and implementation of GPS and its WAAS augmentations. Findings from the NSTB help the FAA develop required user equipment through avionics manufacturers, continue development of GPS user procedures, and gain international acceptance of a seamless Global Navigation Satellite System (GNSS).

Using the NSTB as a prototype system, the program is developing and implementing the capability to monitor and evaluate system performance of the basic GPS service (as well as WAAS) during implementation activities. During these evaluations, large quantities of complex, technical data will be collected, analyzed, and archived. The data will be made available to the FAA and other Government Agencies—as well as to industry, academia, and international entities—to facilitate information exchange, foster cooperation around the world, and achieve a seamless global air navigation system.

The results of this "live" data collection and analysis will assist the FAA in: (1) analyzing and defining the satellite-based navigation technology requirements of air traffic and airway facilities; and (2) determining connectivity and interoperability requirements for international augmentation systems being developed by other countries. The information obtained from these performance evaluations will also allow the FAA to monitor the WAAS system contractor performance during interim contractor maintenance and logistics.

When the Phase I WAAS becomes operational in the Fall 2000, the FAA plans to approve the use of GPS as a primary means of navigation for enroute through non-precision approaches and supplemental use for Category I precision approaches. This initial WAAS capability will increase the numbers of airfields with a precision approach capability, and eventually enable the decommissioning of some existing ground-based navigation equipment throughout the U.S.

The Local Area Augmentation System (LAAS) Test Prototype (LTP) system is being used to test and validate the expected performance of the LAAS systems. The LAAS is intended to complement the WAAS, and the systems function together to supply users of the NAS with seamless satellite based navigation for all phases of flight. The LAAS will be used to meet Category I Precision Approach requirements at those locations where WAAS is unable to meet those requirements. LAAS will also be used to meet the more stringent Category II/III requirements at selected locations throughout the U.S. LAAS will yield the extremely high accuracy, availability, and integrity necessary for Category II/III precision approaches. It is fully expected that the end-state configuration will pinpoint an aircraft's position to within one meter or less.

The FAA has developed and provided a functional Category I LAAS specification, architec-

ture, and Minimum Operational Performance Standards (MOPS) to industry for implementing local area systems across the United States. The FAA will validate the capability to perform Category II/III precision approaches through continued research and development efforts associated with the LAAS Program. An LTP has been developed, and is being used to conduct nationwide flight tests in cooperation with several end-state users of LAAS technology including United Parcel Service (UPS) and Federal Express (FedEx).

Customer/Stakeholder Involvement:

The program's implementation strategy involves other Government Agencies, industry, and academia.

The FAA has established and continues to actively participate on various teams addressing immediate needs for operational implementation issues. These include the Satellite Operational Implementation Team (SOIT), Satellite Procedures Implementation Team, Air Traffic SOIT (AT-SOIT), and many other Teams and working groups.

The FAA has also founded the Technical Interoperability Working Group (IWG) in which the developers of all worldwide satellite based augmentation systems (SBAS) (U.S. WAAS, the European Geostationary Navigation Overlay Service [EGNOS], Japan MSAS, and Canadian WAAS) meet on a quarterly basis to identify and address all of the potential technical barriers to seamless travel between any of these systems. These meetings began in 1997 and are expected to continue until approximately 2001-02.

The FAA works cooperatively with the Positioning and Navigation Executive Committee, the Joint Precision Approach and Landing System Program, and the Department of Defense to establish and promote a national consensus on GPS management and operation. The FAA also provides active support to the Interagency GPS Executive Board (IGEB) regarding overall GPS modernization issues.

Accomplishments:

On September 2, 1999 the FAA Joint Resource Council (JRC) meeting was held to decide the future direction of satellite navigation programs. This forum also considered information from the recently performed and congressionally mandated Investment Analysis. The JRC reaffirmed the FAA's commitment to satellite-based navigation; approved the WAAS Acquisition Program Baseline (APB); approved additional satellite leasing preparatory activities; and kept the current 1998 baseline in effect for LAAS. The LAAS accelerated baseline will be considered as a part of the FAA's Affordability Analysis.

This year, the development of WAAS continued to achieve many significant program milestones. One key milestone set was a series of WAAS signal-in-space (SIS) software builds.

Build 1 (Stability Build) required continuous operation for 72 hours and was completed two weeks early in April 1999. Build 2 (Full Functionality Build) added the fast, long-term, and ionospheric corrections and demonstrated 70+ hours of continuous operation in June 1999. Build 3 (Performance Build) required a fully functional and usable signal in space with integrity that would be operational continuously for eight days. This Build was successfully completed four days early in August 1999. The final and 4th software configuration item (corrections and verification) completed Formal Qualification Testing (FQT) in September 1999.

The resulting WAAS signal-in-space provides accuracies well within the range required by the WAAS specification.

Several flight trials took place in FY 1999 using the NSTB, WAAS signal in space, and the LTP. In October 1998, a series of WAAS test flights at Iceland's Keflavik Airport was conducted using signals from both the NSTB and a European satellite test bed. These flight trials assessed many of the interoperability issues that currently exist between the WAAS and EGNOS.

In December 1998, the FAA conducted WAAS test flights in Santiago, Chile to support the commitment by the Chilean Director General of Civil Aviation to the implementation of WAAS in Chile, as well as the eventual progression of WAAS throughout the entire Caribbean and South American Region (CAR/SAM).

To further support this expansion of WAAS to the CAR/SAM region, the FAA has secured letters of intent from Mexico and Panama for participation

in the operational U.S. WAAS. Additionally, both countries signed bilateral agreements for the installation of NSTB reference stations to be used to prepare for the installation of operational WAAS reference stations in the near future. Related uses of the reference stations include pre-operational support, technology familiarization, flight tests, certification activities, procedure development, and siting analyses. These agreements will significantly cut the FAA's expenses by reducing the agency's need to field WAAS reference stations along the southern U.S. border.

In May 1999, the FAA, with support from the Civil Aviation Authority of Singapore, installed an NSTB reference station and master station at Singapore Changi Airport and performed flight tests to demonstrate the potential benefits of the WAAS within the Asia Pacific region.

In July 1999, the FAA assisted the International Civil Aviation Organization (ICAO) with plans and strategies for the development of a WASS/LASS-based GNSS test bed capability for the CAR/SAM region. The resulting South American Test Bed (SATB) will pave the way for an operational system in the region that is completely compatible with the U.S. systems. This future capability based on U.S. technology will also provide cost-sharing opportunities on GEO satellite services, significantly reducing projected FAA leasing expenses for end-state WAAS GEOs.

In September 1999, the FAA conducted a series of flight trials using the Raytheon WAAS Test Signal. This was the first demonstration flight for any audience (domestic or international) that used the current Raytheon WAAS Test Signal.

The successful completion of all of these flight tests and other activities helped to: (1) demonstrate U.S. technological leadership in satellite navigation; (2) ensure the seamless transfer from one regional satellite-based navigation system to another; (3) promote the adoption satellite-navigation in regions where improved navigation capability will increase the safety of flight for U.S. citizens traveling abroad. It will provide the groundwork necessary to achieve the International Civil Aviation Organization's vision of a future, worldwide, seamless, navigation capability.

Research and development activities to use LAAS to achieve Category I and Category III precision approaches progressed substantially through the use of the LAAS Test Prototype (LTP). Tests using the LTP were completed with excellent results at various locations around the nation.

In August 1999, the FAA in conjunction with UPS and the Air Transport Association (ATA) conducted approximately 40 precision approaches using a wide-body aircraft and the LTP. These tests had very positive results for the use of LAAS and its pseudolite technology on wide-body aircraft. All previous tests were conducted on narrow-body aircraft.

In October 1999, the FAA in conjunction with FedEx and ATA conducted further wide body flight testing at Memphis International Airport. The purpose of these tests was to verify the reception of the airport pseudolite (APL) signal by a wide body aircraft (MD-10) and the ability to accurately range from that signal. A total of 45 precision LAAS approaches were conducted to all six runway ends. Results of the test indicated the typical horizontal navigation system error (NSE) estimate was less than one meter, and the vertical NSE was less than two meters. These results are well within LAAS requirements. These successful flight tests demonstrated the potential of this new technology and the significant contribution LAAS will make to the advancement of satellite-based aviation.

The LAAS Integrity Monitoring Test Bed (IMT) is another tool currently being utilized to validate LAAS requirements and performance. The final version will be deployed at San Francisco International Airport for ground data collection.

Furthermore, LAAS Category I development is proceeding forward. Government Industry Partnerships (GIP) reflecting this effort were signed with Honeywell and Raytheon in April 1999. The LAAS Category I Specification was finalized and approved in September 1999. The Category I MOPS is expected to be approved by February 2000. Category II/III research and development efforts are continuing. LAAS development is ongoing with an initial public use expected for mid-2002 for Category I and late 2005 for Category III.

R&D Partnerships:

The FAA has approximately 20 grants, interagency agreements, and contracts in place with industry, academia, and other government agencies to leverage their expertise and capabilities in satellite navigation R&D. Principal participants include Stanford University, Ohio University, the Naval Air Warfare Center Aircraft Division (NAWCAD), and the Central Intelligence Agency (CIA).

In addition, 15 cooperative bilateral agreements are in place, with additional agreements currently in work, to facilitate and promote the communication and information transfer for a seamless global navigation satellite system.

MAJOR ACTIVITIES AND ANTICIPATED FY 2000 ACCOMPLISHMENTS:

- Performed data collection and analyses using the NSTB to further develop WAAS performance-assessment capabilities.
- Performed data collection and statistical analyses of initial WAAS performance capabilities, including developing WAAS antenna interference mitigation and rejection methods, a safety processor to meet FAA certification standards, and analyzing satellite alternatives for WAAS final operating capability.
- Continued to conduct ionosphere data collection and analysis to define WAAS final operational capabilities.
- Continued research into signal quality monitoring, operations and maintenance, flight control monitoring, and automatic dependent surveillance with participation from Stanford and Ohio Universities.
- Continued investigation studies and analysis for surface movement guidance, helicopter operations, and advanced LAAS augmentations using pseudolites.
- Continued to develop and mature the LAAS integrity algorithms.
- Continued installing and testing LAAS prototype systems at several sites to ensure that the systems will validate the functional specification in particularly difficult sites.
- Continued to demonstrate and test international connectivity as a transition to a seamless global navigation system.
- Initiated investigation studies for surface movement guidance, helicopter operations, and advanced LAAS augmentations.
- Continued to coordinate with ICAO to produce SARPS to define LAAS in the international community.
- Continued interference analysis to identify and mitigate potential threats.
- Continuation/Completion of LAAS Category I Specification Validation efforts.

KEY FY 2001 PRODUCTS AND MILESTONES:

- Define optimum SatNav architecture for Alaska.
- Investigate satellite anomalies.
- Develop WAAS performance monitoring and assessment capabilities.
- Define assumptions and parameters for worldwide Service Volume Model (SVM).
- Define and test SBAS interoperability scenarios.
- Support development of WAAS ionospheric algorithm to be incorporated beyond initial operational capability.
- Validate LAAS Category I Integrity.
- Develop LAAS Category II/III Algorithm.
- Implement and test LAAS Category II/III.
- Develop and validate LAAS Category III Specification.
- Validate LAAS Category II/III Integrity Monitoring/SARPS.
- Develop Improved Signal Quality Monitoring Techniques for CAT III LAAS.
- Investigate Ephemeris Monitoring requirements for CAT III LAAS.
- Develop Airport Pseudolite Integration Techniques.

FY 2001 PROGRAM REQUEST:

In FY 2001, the program will continue to focus on developing and implementing GPS augmentations to further the transition to satellite-based navigation technology. Efforts will focus on research and analysis of issues associated with accuracy, integrity, and availability to the users, with specific emphasis on the ionosphere and interference to ensure service continuity of service. Current research efforts will focus on better utilization of present and future global navigation satellite systems, analysis of LAAS VHF data broadcast characteristics and LAAS category I/II/III evaluations at various locations across the country.

The FY 2001 request of $6,900,000 will focus primarily on the research and development efforts currently being performed by Stanford University, Ohio University and JPL. This will allow the FAA to continue to meet its objectives to transition to satellite-based navigation.

Navigation Product and Activities	FY 2001 Request ($000)	Program Schedule					
		FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY2005
Navigation							
Wide Area Augmentation System (WAAS)	$2,900						
Perform Data Collection and Analyses Using the National Satellite Test Bed (NSTB) to Further Develop WAAS		◆	◇	◇	◇	◇	◇
Continue to Conduct Ionosphere Data Collection and Analysis to Define WAAS Final Operational Capabilities and Support the Development of Enhanced WAAS Ionospheric Algorithm		◆	◇	◇	◇	◇	◇
Define Optimum Architecture for Alaska		◆	◇	◇	◇	◇	◇
Investigate Satellite Anomalies							
Continue Interference Analysis to Identify and Mitigate Potential Threats		◆	◇	◇	◇	◇	◇
Develop WAAS Performance Monitoring and Assessment Capabilities		◆	◇	◇	◇	◇	◇
Define Assumptions and Parameters for Worldwide Service Volume Model							
Perform Interoperability Analyses to Support Seamless Global Navigation Satellite System (GNSS)							
Local Area Augmentation System (LAAS)	$4,000						
Validate LAAS Category I (CAT I) Integrity		◆	◇	◇	◇	◇	◇
Develop LAAS CAT II/III Algorithm		◆	◇	◇	◇		
CAT II/III Implementation and Testing		◆		◇	◇	◇	◇
Develop Improved Signal Quality Monitoring Techniques for CAT III LAAS		◆		◇	◇	◇	
Develop Improved Integrity Algorithms for CAT III LAAS		◆				◇	◇
Investigate Ephemeris Monitoring Requirements for CAT III LAAS							
Develop Airport Pseudolite Integration Techniques							
Total Budget Authority	$6,900	**	$6,900	$5,700	$5,700	$5,700	$5,700

Note: Out year numbers are for planning purposes only. Actual funding needs will be determined through the annual budget process.

Budget Authority ($ in Thousands)	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Enacted	FY 2001 Request
Contracts	10,772	10,426	10,718		6,900
Personnel Costs	1,849	2,466	2,277	**	***
Other Costs	379	505	0		***
Total	13,000	13,397	12,995		6,900

** By Congressional direction, budget line item 1F01 was reduced in FY 2000. The allocation of that reduction is currently under review.

*** In the Facilities and Equipment appropriations, personnel and other costs are budgeted in Activity 5, not the program budget line item.

F&E 1F01— Surveillance

GOALS:

Intended Outcomes: The FAA plans to improve system efficiency and safety by implementing a low-cost surveillance system that enables Free Flight capabilities and enhances safety and efficiency. This program evaluates specific applications of Automatic Dependent Surveillance - Broadcast (ADS-B) and develops domestic and international ADS-B standards to facilitate global system interoperability.

The system uses an onboard Global Navigation Satellite System (GNSS) receiver or other backup source of navigation data to derive the identity, altitude, and position of an ADS-B-equipped aircraft in the vicinity of the airport. These data are broadcast directly to ground receivers as well as to nearby aircraft. An ADS-B message displayed on a neighboring aircraft's airborne Cockpit Display of Traffic Information (CDTI) facilitates the flight crew's situational awareness, conflict detection, and Free Flight capabilities.

The ADS-B technology's modular design and cooperative nature offer a low cost alternative to the surveillance coverage in existing nonradar areas, and potentially, in some areas currently served by radars. Through accurate and timely updates directly to pilots, the system offers the potential to reduce current separation standards while still improving overall safety, efficiency, and airspace capacity.

Agency Outputs: Current efforts focus on validating the capabilities of ADS-B and also on developing standards for the system's avionics, its applications, CDTI and transponders. Standardization efforts include RTCA minimum aviation system performance standards, minimum operational performance standards, technical standard orders, and design criteria. International standards such as the International Civil Aviation Organization's (ICAO) Standards and recommended Practices (SARPS) will also be developed. Outputs will include evaluation of operational procedures outside the scope of Safe Flight 21, procurement specifications for ground systems, deployment of system prototypes, and revised operational procedures.

Customer/Stakeholder Involvement: Air carrier and general aviation user communities have asked for FAA leadership in developing ADS-B technology. The FAA and the user community are actively involved in the standards development activity at RTCA SC 186. Some of the specific stakeholders include the Cargo Airline Association, Experimental Aircraft Association, Air Transport Association, Airline Pilots Association, Aircraft Owners and Pilots Association, United Airlines, Northwest Airlines, and the ICAO's panels and European Work Group on ADS-B.

Accomplishments: Draft ADS-B avionics standards development has been initiated at RTCA. Additional engineering prototype, flight tests, and certification work, including development and test/validation, is required to complete these standards. A cooperative Research and Development Agreement (CRDA) is being planned with United Airlines or an evaluation of selected operational enhancements.

R&D Partnerships: The joint government/industry committee, RTCA SC-186, is tasked with achieving R&D consensus on system standards for ADS-B. Massachusetts Institute of Technology's Lincoln Laboratory, MITRE, and FAATC are also jointly involved in the technical development and integration of ADS-B technology into the NAS.

MAJOR ACTIVITIES AND ANTICIPATED FY 2000 ACCOMPLISHMENTS:

- Completed development of ADS-B 1090 MHz MOPS with RTCA (version 1).
- Developed initial draft of ADS-B/CDTI Minimum Operational Performance Standards (MOPS) with RTCA (version 1).
- Completed spectrum analysis of ADS-B 1090MHz.
- Completed report on flight test of ADS-B 1090MHz at LAX.
- Conducted flight test of ADS-B 1090MHz at Frankfurt Germany and EUROCONTROL sites.
- Conducted pilot and controller simulation of paired approach procedure.

KEY FY 2001 PRODUCTS AND MILESTONES:

- Provide update to RTCA ADS-B 1090 MHz MOPS and ICAO SARPS on extended squitters.
- Continue evaluation of ADS-B/CDTI operational procedures.
- Complete version 1 of draft RTCA ADS-B MOPS on Airborne Surveillance and Separation Assurance Processing.
- Publish draft ADS-B/CDTI standards (version 2).
- Complete operational safety assessment of ADS-B.

FY 2001 PROGRAM REQUEST:

The FAA and RTCA will continue to update RTCA 1090MHz MOPS and complete version 2 of the ADS-B avionics standards for CDTI. Version 1 of the draft RTCA MOPS on Airborne Surveillance and Separation Assurance Processing will be completed. Updates will be provided to ICAO SARPS on extended squitter. Studies, analyses, and field tests will validate paired approach procedures.

Surveillance Product and Activities	FY 2001 Request ($000)	Program Schedule					
		FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY2005
Automatic Dependent Surveillance-Broadcast (ADS-B)							
Plans, Standards, and Analysis							
Minimum Operational Performance Standards (MOPS) and Standards and Recommended Practices (SARPs)	$432						
Update RTCA UAT MOPS		◆	◇	◇	◇		
Provide Initial RTCA UAT MOPS		◆	◇	◇	◇		
Provide Technical Support to RTCA MOPS on Traffic Information System - Broadcast							
Update RTCA MOPS on Surface Guidance and Control							
Update ICAO SARPs and Documents on Extended Squitters							
Performa Simulation evaluation of ADS-B Procedures and Algorithms	$1900						
Final Approach Spacing			◇	◇			
Surface Situation Awareness			◇	◇			
Runway and Final Approach Occupancy Awareness			◇	◇			
Analyze Architecture of Multi-Link ADS-B Ground Station	$300	◆	◇	◇			
Total Budget Authority	$2,632	**	$2,632	$2,800	$500		

Note: Out year numbers are for planning purposes only. Actual funding needs will be determined through the annual budget process.

Budget Authority ($ in Thousands)	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Enacted	FY 2001 Request
Contracts	0	0	3,506		2,632
Personnel Costs	0	0	784	**	***
Other Costs	0	0	0		***
Total	0	0	4,290		2,632

** By Congressional direction, budget line item 1F01 was reduced in FY 2000. The allocation of that reduction is currently under review.

*** In the Facilities and Equipment appropriations, personnel and other costs are budgeted in Activity 5, not the program budget line item.

F&E 1F01 — Airspace Management Laboratory

GOALS:

Intended Outcomes: The Air Traffic Airspace Management Program Office (ATA) is fundamentally responsible to ensure that the national airspace is designed effectively and efficiently. The AT Airspace Laboratory reports to the ATA with continuing tasking to:

- Identify issues and perform analyses, with appropriate environmental evaluations, to support ATA in its airspace design activities. This responsibility includes the development of airspace designs to resolve current as well as future problems through use of currently available and emerging technologies and procedures.
- Support the current and future automation of ATA and other FAA operations. The Laboratory will continue to build automated systems to support such initiatives as overflight "fee for service" assessments and obstacle evaluation.
- Serve as the agency's repository and redistribution center for air traffic data. The Laboratory currently provides ETMS data to various FAA activities, including the Consolidated Operations and Delay Analysis System and the Daily Measurement of Air Traffic Service. The laboratory will expand its sources and distribution of data as needed.

The vision for the AT Airspace Laboratory is that the laboratory will provide data and analysis of the highest caliber and in the most timely manner to meet the needs of AT, as well as other FAA organizations and stakeholders.

Agency Outputs: The AT Analysis Laboratory was initially developed as a proof-of-concept prototype that would be used to identify issues and perform analyses in airspace design activities and environmental evaluations. Existing outputs include:

- Quantitative and qualitative analysis of current NAS performance.
- Integration of local and regional airspace design concepts into a system-wide national level scope.
- Environmental evaluations of alternative airspace configurations.
- Examination of new technology or procedures with respect to potential for performance improvements.
- Acquisition, storage, distribution, and information extraction of air traffic operational data.
- Development of systems to support various FAA and non-FAA lines of business, such as:
  - Obstruction evaluation
  - Overflight fee for service assessments
  - Foreign Overflight Notification System (for DOD)
  - The Consolidated Operations and Delay Analysis System (CODAS)
  - The Daily Measurement of Air Traffic Service (DMATS)

While airspace changes have been analyzed and implemented for decades at the local level, a systematic, comprehensive national analysis has not been performed and no overall national design has been implemented. Significant changes in avionics and air traffic control technology, coupled with continuing changes in the type, amount, and distribution of traffic, have created a need to study and redesign the nation's airspace for current and future use. It is particularly likely that airspace redesign will be required to complement FAA's implementation of global positioning navigation systems, Free Flight Phase I sequencing tools, and dynamic sectorization.

Customer/Stakeholder Involvement: Successful demonstration of the AT Analysis Laboratory capability has shown benefits across multiple lines of business. In addition to the Airspace Management Program Office (ATA), the Office of System Architecture and Investment Analysis (ASD), the Office of System Capacity (ASC), Air Traffic Planning and Procedures (ATP), and Air Traffic System Management (ATM), the Lab has supported the missions of the Cost Accounting Team, the Office of Financial Services, the Office of Aviation Policy, and the Y2K Contingency Planning Work group. The capability exists in demonstration and prototype and an opportunity

is in place to develop this capability into a full mission analysis and support laboratory.

The Laboratory also has provided on-going support for numerous projects of the FAA Eastern Region (AEA) involving field analyst staffing, analytical work, daily access to operational data, and continuing technical support for database query programming.

The AT Laboratory has been identified as the element responsible for supporting airspace design dependencies for FAA F&E programs with broad government and industrial involvement, including:

- Local-Area Augmentation Systems (LAAS) — all category approaches.
- Low Altitude Direct Routing using Wide-Area Augmentation Systems (WAAS).
- Runway Incursion Program.
- WAAS Precision Approaches.
- Automatic Dependent Surveillance (ADS) studies.
- Single and Multi-center metering.
- Final Approach Spacing Tool (FAST) implementation studies.
- New Host Consolidation/Dynamic Resectorization studies.

Accomplishments:

Airspace issue identification.

- Tracked critical parameters for proactive identification of issues
- Visualized/analyzed past and current traffic patterns
- Analyzed system performance

Airspace design and environmental evaluation.

- Developed alternative airspace designs for examination
- Analyzed changes to airspace design on flow, capacity, delay, workload, and other metrics as required
- Developed data necessary to evaluate noise and consider pollution impacts to complement airspace design analysis

R&D Partnerships: Organizations that will use or support the laboratory include the Office of System Architecture and Investment Analysis (ASD), the Office of System Capacity (ASC), Air Traffic Planning and Procedures (ATP), and Air Traffic System Management (ATM).

MAJOR ACTIVITIES AND ANTICIPATED FY 2000 ACCOMPLISHMENTS:

- Developed national listing of aircraft diversions
- Developed New York and Washington metro area arrival and departure fix reports
- Provided analytical support with two operational studies:
  - Comparison of sector densities from four Aircraft Management Program (AMP) based systems—OAMP, HAME, STT, and PCOAT
  - Review of the Staffing to Traffic (STT) data (Input Data, Air Traffic Activity Measures, and Output Reports. (See CNAC reports CRM 95-22 and CRM 94-128.)
- Performed analytical work/studies on behalf of Eastern Region
- Provided SDAT support with sector analysis studies
- Developed concept papers on a range of topics, including:
  - Concept for a Field-Level Traffic Management Unit Operational Test, Evaluation and Development Capability
  - En-route Sector Spacing Tool
  - Smart Log and Lessons Learned

KEY FY 2001 PRODUCTS AND MILESTONES:

- Perform quantitative and qualitative analysis of current NAS performance
- Integrate local and regional airspace design concepts into a system-wide national level scope
- Conduct environmental evaluations of alternative airspace configurations
- Examine new technologies or procedures with respect to potential for performance improvements

- Acquire, store, distribute, and extract information from air traffic operational data
- Develop systems to support various FAA and non-FAA lines of business

FY 2001 PROGRAM REQUEST:

Airspace Management Lab Product and Activities	FY 2001 Request ($000)	Program Schedule					
		FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY2005
Develop Systems to Support FAA and non-FAA lines of business	$2,400	◆	◇	◇	◇	◇	◇
Data Collection, Analysis and Reporting of Current NAS performance	$1,600	◆	◇	◇	◇	◇	◇
Total Budget Authority	$4,000	$3,000	$4,000	$4,000	$5,000	$5,000	$5,000

Note: Out year numbers are for planning purposes only. Actual funding needs will be determined through the annual budget process.

Budget Authority ($ in Thousands)	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Enacted	FY 2001 Request
Contracts	0	0	0		4,000
Personnel Costs	0	0	0	**	***
Other Costs	0	0	0		***
Total	0	0	0		4,000

** By Congressional direction, budget line item 1F01 was reduced in FY 2000. The allocation of that reduction is currently under review.

F&E 1F01 — ATC/ATM Decision Support Tools

GOALS:

Intended Outcomes: Through this program, the FAA intends to increase the capacity of the National Airspace System in all weather conditions, without negatively impacting safety. Specifically, this research supports the FAA System Efficiency Mission Goal regarding the reduction of system delays and contributes to the achievement of the first three outcomes of the ATS Performance Plan:

- Outcome 1 - Increase System Safety—by aiding in the sequencing and spacing of aircraft, reduces the risk of operational errors and deviations.
- Outcome 2 - Decrease System Delays—decision support tools resulting from this research will allow more flights to land and takeoff at our nations airports during peak usage periods.
- Outcome 3 - Increase System Flexibility—the tools will allow more effective flight planning resulting in more direct routing of flights.

Some of the decision support tools developed by prior research are being implemented on a limited basis in selected FAA facilities and participating airline operational centers (AOC). Examples include: the Final Approach Spacing Tool (FAST), the User Request Evaluation Tool (URET), the Traffic Management Advisor (TMA), and the Surface Movement Advisor (SMA). Benefits from the use of these tools are expected to contribute to the FAA Strategic Plan System Efficiency Goal of reducing the rate of volume delays by 20 percent and should aid the FAA in attaining its Strategic Plan Safety Goal of an 80-percent reduction in the US aviation fatal accident rate.

The requested research program will support the development of the next generation of decision support tools and the information exchange networks that the NAS Architecture 4.0 anticipates to enter full-scale development by 2008. Successful development and implementation of these next generation tools are projected to yield an additional 10 to 20 percent reduction of NAS volume delays (Strategic Plan System Efficiency Goal) and contribute substantially to the goal of an 80-percent reduction in the accident rate (Strategic Plan Safety Goal).

Agency Outputs: As envisioned by the NAS Architecture, this research will lead to designs for: decision support tools for use by air traffic controllers in the enroute, terminal, and surface environments; decision support tools for use by FAA ATM operations and the airline AOCs in the strategic and tactical management of the flow of air traffic; and decision support tools for use by the flight crews as participants in the NAS.

Some of the major projected concept demonstration outputs of this research follow:

- The TMA Multi-Center Tool.
- Dynamic Density Monitor, Compliance Monitor, and System Impact Assessment tools.
- Integrated surface surveillance and movement planning systems, low visibility surface guidance and movement monitoring systems.
- Integrated enroute, terminal and surface decision support tools and their combined impact on the gate-to-gate performance of the NAS.
- Enhanced Center TRACON Automation System (CTAS) and URET tools that provide controllers and managers with sequencing, spacing, and separating alternatives (e.g. Active FAST, Conflict Resolution Advisory and others) with enhanced linkages to weather systems.
- Dynamic Wake Vortex Spacing Tool.
- Integrating aircraft FMS with ground side decision support tools.

The research also is expected to result in: the specification of requirements for linking decision support tools to the NAS Wide Information Network; and the high fidelity modeling and simulation of decision support tool performance when coupled with the aircraft flight management systems (FMS).

R&D Partnerships:

NASA is a full partner in this research with its ongoing Terminal Area Productivity, Advanced Air Transportation Technologies, and Advanced General Aviation Technologies Experiment projects. The Center for Advanced Aviation System Development (CAASD) has

been conducting decision support tools research for the FAA over the past several decades and will continue to work on this research agenda. NASA and FAA/CAASD research efforts are coordinated through the Interagency ATM Integrated Product Team (IAIPT).

The separately funded research proposed herein is both in concert with the planning of the IAIPT and necessary if NASA and FAA/CAASD research efforts are to be integrated into products that the FAA's capital investment program and the aviation industry can fully implement. Contract funding is required to establish the environment for the NASA and CAASD concept exploration and demonstration work. This includes tool adaptation for the demonstration phase, controller and ATM evaluation of the concept demonstration tools, high fidelity simulations of concept alternatives, experimentation with tool integration, interface testing to ensure non-interference with center and/or TRACON operations, and performance validation.

EUROCONTROL is also pursuing research in the development of ATM decision support tools. This requested research project (and associated contract support funding) is additionally in support of joint FAA/EUROCONTROL agreements in the development of decision support tools for ATM/ATC.

MAJOR ACTIVITIES AND ANTICIPATED FY 2000 ACCOMPLISHMENTS:

- Evaluated NASA's Direct-To Decision Support Tool.
- Explored TMA Multi-Center Tool application to Northeast Corridor.
- Planned for Conflict Resolution Tool demonstration at the William J. Hughes Technical Center (WJHTC).
- Participated in FAA/EUROCONTROL Conflict Detection/Resolution Technical Interchange Meeting.
- Developed and received approval for TMA Multi-Center Research Management Plan.
- Developed and received approval for the Enroute Conflict Resolution Research Management Plan.
- Developed Research Management Plan for Surface Management Tools.

KEY FY 2001 PRODUCTS AND MILESTONES:

- Complete the scenario build for the TMA Multi-Center Tool.
- Complete the concept exploration for the Surface Decision Support tools.
- Complete the modeling of alternatives for the integration of Enroute, Terminal and Surface tools.

FY 2001 PROGRAM REQUEST:

In the immediate future, the volume of air traffic movement is projected to grow by more than 3 percent per year. To service this growth, the nation must increase the size of its aviation infrastructure, develop methods to employ its existing infrastructure more effectively or turn to some combination of these strategies. Putting existing infrastructure to better use is the most cost efficient strategy for the nation and is the focus of this research. Unless the proposed research tasks are funded, the decision support tools concept exploration work by NASA and FAA/CAASD will not result in products that can be cost effectively integrated into the FAA's NAS modernization program.

The Airport Technology FY 2001 research program is a collaborative effort among many government organizations, universities, and industry associations. The program funding requested provides the contract support necessary for an integrated, effective research program that delivers the standards and guidelines for maintaining and enhancing airport infrastructure.

ATC/ATM Decision Support Tools Product and Activities	FY 2001 Request ($000)	Program Schedule					
		FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY2005
ATC/ATM Decision Support Tools							
Traffic Management Advisor (TMA) Multi-Center - Complete Scenario Build	$338	◆	◇				
TMA Multi-Center - Demonstration	$127	◆	◇				
Complete Surface Decision Support Tools Concept Exploration	$212						
Complete Development of Demonstration System		◆	◇	◇	◇	◇	◇
Demonstration and Evaluation		◆	◇	◇	◇	◇	◇
Integrate En Route, Terminal and Surface Tools	$169						
Complete Modeling of Alternatives		◆	◇	◇	◇		
Complete Simulation of Selection Alternative		◆		◇	◇	◇	◇
Complete Demonstration Design		◆		◇	◇	◇	
Complete Demonstration - Complete Analysis		◆	◇		◇	◇	◇
Demonstrate FMS/CTAS/URET Integration Concept		◆		◇			◇
Total Budget Authority	$846	**	$846	$900	$1,000	$1,000	$1,000

Note: Out year numbers are for planning purposes only. Actual funding needs will be determined through the annual budget process.

Budget Authority ($ in Thousands)	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Enacted	FY 2001 Request
Contracts	0	0	0	0	846
Personnel Costs	0	0	0	0	***
Other Costs	0	0	0	0	***
Total	0	0	0	0	846

*** In the Facilities and Equipment appropriations, personnel and other costs are budgeted in Activity 5, not the program budget line item.

F&E 1F01 — Separation Standards

GOALS:

Intended Outcomes: The Separation Standards Program works to reduce separation standard values within international airspace to make the following benefits available to providers and users of oceanic air traffic control systems:

- Increased system efficiency—evidenced through reduced aircraft fuel-burn and transit times.
- Increased theoretical system capacity—evidenced through an increase in the number of routes and flight levels that controllers can safely support within the same volume of airspace.
- Increased international standardization of separation criteria and resultant enhanced system safety.

Agency Outputs: The FAA's "Strategic Plan for Oceanic Enhancements and Separation Reductions" describes a systematic process for revising international separation values and establishes priorities for such changes. To document and evaluate each separation change, the FAA produces a series of supporting products:

- Operational assessments of the value the change brings to Air Traffic Control (ATC) system providers and users.
- Benefit-cost analysis regarding the change.
- Safety assessment of the system before and after application of the separation change.
- Publication of FAA regulatory material required by the change.
- Completion of any new rulemaking required by the change.
- Development of ATC procedures required by the change.
- Development of any new or changed International Civil Aviation Organization (ICAO) guidance material, annexes, or regional supplementary procedures required to standardize and make the reduced separation value safe for international operations.
- Establishment and maintenance of any long-term safety oversight functions required for the implementation and continued safe use of the reduced separation value.

Customer/Stakeholder Involvement: The Separation Standards Program establishes appropriate ICAO- government-industry forums to draw all parties concerned with a change in separation standards into a common process. The cooperating entities may include: state Civil Aviation Authorities (CAA), ICAO regional and Headquarters elements, ATS providers, ATC system users, industry trade organizations, and unions representing controllers and pilots.

Participants in specific change processes include:

- *Pacific separation standards.* Changes proceed with the coordination and endorsement of the (North Pacific) Oceanic Work Group, Informal (North) Pacific ATC Coordinating Group, and Informal South Pacific ATS Coordinating Group, as well as the ICAO Pacific Reduced Vertical Separation Minimum (RVSM) Task Force.
- *North Atlantic separation standards.* Changes are carried out through the ICAO regional planning group, the North Atlantic Systems Planning Group.
- *West Atlantic Route System Separation Standards (WATRS).* Proposed improvements involve participation of the New York Oceanic Capacity Enhancement Task Force.

The program also provides FAA representation on ICAO's Review of the General Concept of Separation Panel (RGCSP)—the focal point for development of the technical justification for new separation minima as well as the forum for assessing application of recommended ICAO separation practices on a global and regional basis.

Accomplishments: The Separation Standards Program has been the vehicle for the FAA to bring about major reductions in separation standard values affecting international airspace. In the past three years, the program has been responsible for several significant changes:

- *North Atlantic RVSM, or 1000-ft. vertical separation standard above flight level (FL) 290 (March, 1997).* Introduction of this change marked the culmination of a 15-year

the FAA and other State CAAs to reduce the high-altitude separation standard. Several studies had predicted that the RVSM would be the single most cost-beneficial separation change possible for oceanic airspace; actual experience has proven that the studies were accurate forecasters of RVSM benefits. Within the first 12 months after RVSM implementation, each of the 10 operators accounting for a combined 60 percent of annual North Atlantic operations had recovered the sunk costs associated with bringing its aircraft into compliance with RVSM requirements.

- *North Pacific 50-nm lateral separation standard based on operator compliance with required navigation performance (RNP)-10 requirements (April, 1998 and December, 1998).* This linkage between a separation standard and an RNP value marked the first use of the ICAO-endorsed concept in any portion of worldwide airspace. The change led to measurable improvements in both ATC operations and aircraft fuel-burn and transit time.
- *North Atlantic Implementation Management Group Cost Effectiveness (NICE) Program (October, 1999).* This comprehensive fast-time-simulation-based assessment of the benefits associated with North Atlantic separation changes proposed through the year 2010 resulted in significant changes. Plans were modified for ATS system infrastructure expenditures and users were held to different schedules and equipage requirements in order to participate in the project within the airspace. The FAA's NICE Program contributions were the result of a combined effort by federal staff members and grant-sponsored university researchers.
- *Pacific RVSM leadership (June, 1997 to present).* Based on FAA encouragement, contributions and previous experience in the North Atlantic, the ICAO Asia and Pacific Region planning group established the Pacific RVSM Task Force to facilitate implementation of the RVSM in February, 2000. The FAA chairs or co-chairs all Task Force working groups and has provided the technical consultation concerning RVSM implementation to States in the Region. The ICAO planning group has agreed that the FAA Technical Center will provide the safety oversight function associated with RVSM implementation and has endorsed establishment of the Asia/Pacific Approvals Registry and Monitoring Organization (APARMO) to carry out this function.

R&D Partnerships: The Separation Standards Program provides FAA representation to ICAO's RGCSP, the principal global forum for moving ahead with the development of new separation minima. The FAA and other CAAs typically cooperate in such work, with each state-participant freely sharing research results within the Panel. In addition, the Separation Standards Program maintains close research ties with academia through sponsorship of grants and cooperative work with Rutgers University in the development of large fast-time simulation models of oceanic airspace. The program also has a direct link with international separation research activities in which the FAA's GPS Monitoring System supports EUROCONTROL's RVSM safety oversight activities. In turn, that international body provides access to the products of its RVSM research.

MAJOR ACTIVITIES AND ANTICIPATED FY 2000 ACCOMPLISHMENTS:

- Emphasis in FY 2000 will be in four major areas:
- Pacific RVSM: with intended simultaneous implementation in all Pacific flight information regions on February 24, 2000.
- Implementation of 50-nm lateral separation standard in the Central East Pacific track system on February 24, 2000.
- Preparations for November 2001 implementation of RVSM in the West Atlantic Route System.
- Establishment of a comprehensive plan to introduce RVSM and horizontal–plane separation reductions in the Gulf of Mexico and the ICAO Caribbean/South American Region.

KEY FY 2001 PRODUCTS AND MILESTONES:

- Finalize the planning and establishment of infrastructure necessary to support November

2001 West Atlantic Route System RVSM implementation.

- Provide limited introduction of a 50-nm longitudinal separation in the Pacific—based on controller-pilot data link communication.
- Complete work within RGCSP to formalize requirements for 30-nm lateral and 30-nm longitudinal separation standards.
- Implement the plan formulated in FY 2000 to reduce separation minima in Gulf of Mexico and ICAO Caribbean/South American Region.
- Continue the safety oversight function in Pacific and North Atlantic.
- Initiate further NICE work to quantify North Atlantic communication requirements associated with reduced separation minima.

FY 2001 PROGRAM REQUEST:

The FY 2001 program request provides for:

- Completion of real-time simulation, procedure development and safety oversight activities necessary to permit November 2001 introduction of RVSM into the West Atlantic Route System.
- Completion of work necessary to finalize requirements for reducing horizontal-plane separation minima to 30-nm—with such requirements anticipated as satisfied by automatic dependent surveillance.
- Expansion of safety oversight assistance beyond the Pacific and North Atlantic— including augmentation of the GPS Monitoring System to support Gulf of Mexico, Caribbean/ South American and possible NAS RVSM implementation
- Completion of NICE Program North Atlantic studies and publication of revised plan for introduction of separation reductions.

Separation Standards Product and Activities	FY 2001 Request ($000)	Program Schedule					
		FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY2005
Separation Standards							
West Atlantic Route System Reduced Vertical Separation Minima (RVSM)	2,200						
Conduct Safety Oversight		◆	◇	◇	◇	◇	◇
Develop Procedures		◆	◇				
Implement		◆		◇	◇	◇	◇
Complete North Atlantic Implementation Management Group Cost Effectiveness (NICE)		◆	◇				
30/30 Nautical Mile Requirements		◆	◇	◇	◇		
Gulf of Mexico (GOMEX) and Caribbean Separation Changes		◆	◇	◇	◇	◇	
Total Budget Authority	2,200	**	$2,200	$2,200	$2,400	$2,500	$2,500

Note: Out year numbers are for planning purposes only. Actual funding needs will be determined through the annual budget process.

Budget Authority ($ in Thousands)	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Enacted	FY 2001 Request
Contracts	1,284	0	0		2,200
Personnel Costs	1,855	0	1,145	**	
Other Costs	0	0			
Total	3,139	0	1,145		2,200

** By Congressional direction, budget line item 1F01 was reduced in FY 2000. The allocation of that reduction is currently under review.

A04 — Weather Program

GOALS:

Intended Outcomes: The FAA intends to provide the capability to generate weather observations, warnings, and forecasts that are more accurate and accessible than existing weather services. These upgrades will enhance flight safety, increase system capacity, improve flight efficiency, reduce air traffic controller and pilot workload, improve flight planning, increase productivity, and enhance situational awareness.

In accordance with the Federal Aviation Act of 1958 as amended, the FAA is responsible, in cooperation with the Department of Commerce, for promoting and developing meteorological science, and for fostering support of research projects through the use of private and governmental research facilities. These duties are further amplified by recommendations contained in an Aviation Weather Services report issued by the National Research Council (1995) and the final report of the Aviation Weather Subcommittee issued by the FAA's Research, Engineering and Development Advisory Committee (October 1995).

The weather program directly supports FAA Strategic Goal #1 in the performance area of Safety: "Through research, identify methods that, when implemented would reduce the fatal accident rate, due to weather."

This weather R,E&D program, in collaboration with National Weather Service (NWS) programs, produces weather algorithms (technology), more rapid forecasting and delivery of forecasts (delivery), and supports the development of aviation weather instructional material (education).

Agency Outputs: The weather program focuses on conducting applied research to solve operational problems through the development of new and improved algorithms. These algorithms, are being developed for implementation on appropriate NAS platforms (including the weather and radar processor, and the integrated terminal weather system) and on NWS systems continue to be transferred to private weather service companies in support of the NAS. This transfer enables companies to derive specialized aviation weather products from FAA research efforts. Algorithm development provides capabilities including:

- Depiction of current and forecasted in-flight icing areas to enhance safety, airspace efficiency, and aircraft utilization.
- Interactive data assimilation, editing and forecast tools to improve aviation advisories and forecasts issued by the NWS.
- Location, timing, and severity of convective weather hazards to improve flight safety and enhance capacity.
- Depiction of current and forecasted precipitation type and rate to enhance safety and efficiency in the terminal area
- Short-term forecasts and prediction of ceiling and visibility in the terminal area for enhanced capacity
- In situ and remote detection and forecast of enroute turbulence including clear air

In addition, through Project SOCRATES, the weather program is developing and deploying sensors to provide a tactical safety net for aeronautical weather-dependent hazards with an initial focus on wake turbulence hazards for closely spaced, parallel runway operations.

Customer/Stakeholder Involvement: The National Aviation Users' Forum has provided a process to develop a federal/industry consensus on their needs and priorities for aviation weather information. Participants in the Forum include representatives from the Airline Pilots Association, United, American, and Delta Airlines, and other industry representatives. This forum serves as a basis to set priorities for research and development as well as system acquisition. The FAA's weather priorities and plans are consistent with users' recommendations made at this forum, and responsive to industry recommendations.

The weather program analyzes aviation weather service users' needs and requirements found in the Aviation Safety Action Plan. It also addresses industry recommendations and requirements found in six or more related documents and publications.

Accomplishments: The following represent major accomplishments of the weather program:

- Rapid update cycle analyses and forecast capabilities providing more accu-

rate and higher resolution upper winds, temperature, and precipitation data. Use of more accurate data on hazardous weather and jet streams has reduced flight times and/or flight delays.

- Issued the first-ever forecast of freezing precipitation aloft at the aviation weather center in Kansas City in response to FAA proposed rulemaking for turboprops flying into conditions conducive to in-flight icing. These forecasts have increased airspace efficiency, aircraft utilization, and safety, especially for commuter aircraft.
- Commenced flight test of humidity sensor on United Parcel Service (UPS) aircraft, as part of the Water Vapor Sensing System (WVSS) program, leveraged with NOAA. The availability of detailed water vapor data in real time will be utilized to make more accurate in-flight icing and ceiling and visibility forecasts.
- Completed upgrades to Next-Generation Weather Radar (NEXRAD) algorithms, storm cell identification and tracking, hail detection, and mesocyclone and tornado detection (leveraged with NWS). These upgrades have enabled better definition of location, timing, and severity of convective weather hazards resulting in enhanced flight safety and capacity.
- Completed storm growth and decay field tests in Dallas and Orlando. This research will result in the accurate short-term prediction of the initiation, growth, and decay of storm cells. It will enhance safety and capacity by improving aircraft avoidance of hazardous weather, resulting in enhanced strategic and tactical flow management planning, allowing more effective routing of traffic to/from airports and runways.
- Transferred Weather Support to Deicing Decision Making (WSDDM) system technology to a commercial weather provider to provide ground deicing decision making information to airlines and cities. WSDDM System information has resulted in increased safety (takeoffs) cost savings in use of deicing fluids/associated equipment/ personnel, and efficiencies in runway and off-airport plowing/departures/arrivals.
- Implemented initial operating capability of the Aviation Gridded Forecast System (AGFS) at the NWS, providing an aviation specific weather database for the aviation community and user access to this data via the Aviation Digital Data Service (ADDS).
- Fabricated and tested a two beam, laser based, acoustic system for wake turbulence detection at JFK Airport under Project SOCRATES.
- Initiated installation of a wake turbulence and wind monitoring system at San Francisco International Airport.

R&D Partnerships: Program activities are closely coordinated and leveraged with industry, academia, and other government agencies. This is done directly through interagency agreements, university grants and Memorandums of Agreement (MOAs). Principal partners include the National Center for Atmospheric Research, NOAA's Forecast Systems Laboratory, Environmental Technology Laboratory and National Severe Storms Laboratory, Massachusetts Institute of Technology Lincoln Laboratory, NWS's Aviation Weather Center and Environmental Modeling Center, Center for Wind, Ice, and Fog Research at the Mount Washington Observatory, NASA Dryden, Langley and Glenn, Office of Naval Research, U.S. Army Cold Regions Research and Engineering Laboratory, and UPS, as well as several universities, airlines, port authorities, and cities.

Research results are transferred to the private sector via cooperative research and development agreements with GTE, Kavouras, WSI, Harris, AccuWeather, Jeppesen, Sonalyst, and Radian.

Project SOCRATES provides direct wake turbulence measurement and support for FAA Air Traffic and Flight Safety capacity and safety initiatives. Wake turbulence activities are also closely coordinated with NASA and international research efforts.

MAJOR ACTIVITIES AND ANTICIPATED FY 2000 ACCOMPLISHMENTS:

- Developed initial integrated icing forecast algorithm.

- Commenced inclusion of turbulence in situ data into forecast models.
- Generated AGFS custom graphics of weather along user-specified flight routes.
- Tested radar improvements to provide rapid updates of hazardous weather.
- Conducted field test of storm growth and decay prediction technology.
- Developed 1-2 hour snow forecast.
- Conducted Juneau project field program with research aircraft.
- Implemented preliminary turbulence forecasting algorithm at the Aviation Weather Center.
- Obtained data in the SOCRATES proof-of-concept and analyzed follow on tests at JFK to define system improvements.
- Completed initial installation of a wake turbulence and wind monitoring system at San Francisco International Airport.

KEY FY 2001 PRODUCTS AND MILESTONES:

- Incorporate satellite data into in-flight icing guidance product.
- Implement AIRMET/SIGMET tools
- Conduct airborne humidity sensor flight demonstration of utility.
- Incorporate boundary layer data into 60-minute storm growth and decay forest.
- Complete in situ based detection turbulence product evaluation.
- Implement a 1-2 hour marine stratus burn off forecast for San Francisco International Airport.
- Implement phase I wind data ingest and dissemation system at Juneau Airport.
- Commence Phase I development of Oceanic Convective Nowcasting manual products.
- Develop west coast haze algorithm.
- Deploy enhanced wake turbulence monitoring system at San Francisco, under Project SOCRATES, to support parallel runway operations under reduced visibility conditions.
- Demonstrate eight-beam SOCRATES laser acoustic sensor.

FY 2001 PROGRAM REQUEST:

- Develop new algorithms for improved forecasts of freezing drizzle aloft, and west coast haze.
- Continue to develop automated data analysis and assimilation techniques.
- Transition weather research products to NWS, the FAA, and industry automation and weather systems.
- Develop oceanic convective nowcasting products.
- Commence national ceiling and visibility program.
- Design, fabricate, and test a SOCRATES eight beam laser acoustic system.
- Incorporate SOCRATES technology into San Francisco wake turbulence monitoring system.
- Provide wake turbulence support for developing terminal procedures for closely spaced, parallel runway operations at major airports.

A04a - Weather Program Product and Activities	FY 2001 Request ($000)	Program Schedule					
		FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY2005
041-110 Aviation Weather Analysis and Forecasting							
Develop Aviation Gridded Forecast System (AGFS)	$2,700						
Generated Custom Graphics of Weather Along User-Specified Flight Routes		◆					
Implement AIRMET/SIGMET Tools			◇				
Implement Interactive Convective SIGMET/AIRMET Ensemble Tools				◇	◇		
In-Flight Icing	$2,146						
Initial Development of Integrated Icing Forecast Algorithm		◆					
Incorporate Satellite Data into In-Flight Icing Guidance Product			◇				
Improve Year-Round Guidance Product and Severity/Type Forecasts				◇	◇		
Winter Weather Research	$617						
Develop Techniques to Detect/Forecast Precipitation Type and Rate, Incorporate Radar/Satellite Data				◇	◇	◇	
Storm Growth and Decay	$3,350						
Conducted Field Test of Storm Growth and Decay Prediction Techniques		◆					
Incorporate Boundary Layer Data, Transition to ITWS			◇				
Demonstrate 90-Minute Forecast				◇	◇		
Turbulence Algorithm	$2,400						
Inclusion of Turbulence Data into Models		◆	◇				
Complete In-Situation Based Detection Product Evaluation			◇	◇			
NEXRAD Algorithms	$1,375						
Tested Improvements for Rapid Updates of Hazardous Weather		◆					
Deliver Dual Polarization Algorithms to OSF					◇	◇	◇
Airborne Humidity Sensor	$300						
Complete Sensor Evaluation/FAA/NOAA Decision on Utility			◇	◇			
Juneau Terrain-Induced Turbulence Project	$3,100						
Implement Phase 1 System			◇				
Implement Operational System					◇		
Ceiling and Visibility	$2,710						
Implement Marine Stratus Burn-Off Forecast at San Francisco International Airport (SFO)			◇				
Model Development and Enhancement	$2,600						
Commence Development of Weather Research & Forecasting Model			◇				
Oceanic Convective Nowcasting	$1,000						
Commence Phase 1 Development of Products			◇				
National Ceiling and Visibility Program	$1,500						
Develop West Coast Haze Algorithm			◇				
Project SOCRATES	$3,200						
Completed Evaluation of 2-Beam SOCRATES System		◆					
Complete Evaluation of SFO Operational Configuration			◇				
Personnel and Other Costs	$791						
Total Budget Authority	**$27,789**	**$19,300**	**$27,789**	**$28,052**	**$28,491**	**$29,115**	**$29,942**

Note: Out year numbers are for planning purposes only. Actual funding needs will be determined through the annual budget process.

Budget Authority ($ in Thousands)	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Enacted	FY 2001 Request
Contracts	11,683	14,500	17,836	18,635	26,998
Personnel Costs	1,093	664	817	629	705
Other Costs	224	136	36	36	86
Total	13,000	15,300	18,684	19,300	27,789

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2.2 Airports Technology Program Area Description

Mission

The U.S. airport system consists of 6 billion square feet of pavement with a replacement value estimated at $100 billion. There are over 600 million passenger enplanements each year at over 17,000 landing facilities with terminal buildings and access roads. Current trends indicate that the aircraft fleet will not only increase in number, but also more importantly, in operating speed, gear loading and configuration, and aircraft size; traffic demands by the year 2010 will have doubled; and airport pavements will need capital improvements costing billions of dollars.

The Airport Technology program's mission is to provide technology solutions that will allow the Nation's airports to accommodate the projected traffic growth and establish an operational environment that is free of accidents and fatalities. This is accomplished by fulfilling the FAA's regulatory obligation (49 U.S.C. 47105(b) 3) to develop standards, criteria, and guidelines for planning, designing, constructing, operating, and maintaining the massive airport system. This includes:

- Airport pavement design
- Airfield design
- Wildlife hazard mitigation
- Visual guidance systems
- Surface traction
- Post-crash rescue and firefighting
- Wildlife control

Intended Outcomes

The most important program outcomes are reducing or eliminating aircraft accidents and lowering the cost of developing and maintaining safe airports.

The Airport Technology program area supports several FAA Strategic Plan goals:

- System Safety: reduce the number of accidents and incidents occurring on or near the airport surface. Current areas of emphasis involve the reduction of incidents in which airport surface condition is a cause or factor, reduction of hazards from wildlife strikes, and reduction of runway incursions and runway transgressions.
- System Capacity: enhance airport capacity.
- Industry Vitality: enhance the vitality and international competitiveness of the U.S. commercial air transportation industry.
- Global Leadership: in cooperation with industry and other Federal agencies, promote U.S. aviation system technologies.
- Environmental Responsibility: create an environmentally effective and responsive FAA both domestically and internationally.

System safety — Reduction or elimination of aircraft accidents and incidents is supported by a comprehensive R&D program. The program seeks to reduce the risk of aircraft sliding off runways due to the presence of water, snow, ice, and man-made surface contaminants such as rubber and anti-icing materials. Improved runway traction is the central focus of this research, which will provide improved methods, materials, and procedures for detecting and removing contaminants from runway surfaces.

The effectiveness of soft-material arrester beds has already been proven in stopping an overrunning aircraft, and the program is developing national standards for design. More economical materials and installation methods must be found, though, to encourage more of these installations. Ongoing research in the area of wildlife control at or near airports seeks methods of reducing hazards from wildlife strikes with the aircraft. This includes cooperative research with the Department of Agriculture in assessing wildlife hazards at airports and maintaining a national birdstrike database.

Continued research in visual guidance systems is necessary to improve the safety of ground operations during daytime, nighttime, and under low-visibility conditions. Pilots and vehicle operators must receive clear and unambiguous information from lights, signs, and markings. Improvements in this area will help eliminate runway incursions and aircraft collisions on airport surfaces. State-of-the-art light sources and applications are nec-

essary to enhance the safety and efficiency of aircraft operations.

Industry Vitality, Global Leadership, and System Capacity — These are supported by a comprehensive research and development (R&D) program for airport pavement design with U.S. and international government and industry support and collaboration. The International Civil Aviation Organization (ICAO) has formally agreed to use the results from the Airport Technology program to develop worldwide pavement design standards.

The FAA's pavement research has the potential to provide large benefits. Approximately $2 billion is spent on constructing, rehabilitating, and maintaining airport pavements each year by Federal, State, and local governments and by airport operators; about $4 million is spent on research. Increasing the pavement life by as little as 10 percent through research would result in a 50 to 1 benefit/cost ratio. This is an attainable goal the program is working to achieve.

ICAO relies heavily on the results of visual aids research performed in the United States. To an increasing extent, visual aids research is being performed in cooperation with the United Kingdom and other European countries in order to reduce costs and to develop uniform international standards.

Research efforts are required to develop strategies for attacking post-crash fires on new multilevel, high-density seating, passenger aircraft being designed by manufacturers around the world. Elevated waterway and boom penetration devices are examples of ways to provide increased passenger survivability and evacuation protection. Training requirements and firefighting simulators must still be developed to fully utilize the new capabilities. ICAO is using research results to develop international firefighting standards.

Program Area Outputs

The airport advisory circular system is the principal means by which the FAA communicates with the user community—the Nation's airport planners, designers, operators, and equipment manufacturers. Advisory circulars (AC) present the standards used in the design, construction, installation, maintenance, and operation of airports and airport equipment. In all projects funded through the Airport Improvement Program (AIP), project work must meet standards set in one of these ACs. This requirement ensures, for example, that the $100 billion investment in airport pavement is protected, by requiring pavement construction to meet standards for design, performance, and durability. In addition, these circulars provide information that promotes safe and efficient operation under adverse weather conditions.

Over 100 ACs have been published on a wide range of technical subjects, including airport design configuration standards, pavement design and material, lighting and navigational aids, firefighting equipment and procedures, pavement condition weather sensors, wildlife control, terminal building design, snow/ice control, and friction-measuring equipment and procedures.

The FAA updates ACs as and when necessary. The information and data collected in our entire Airport Technology R&D program culminates in the updated ACs.

Program Area structure

Various elements of the Airport Technology program area affect the safety and operation of aircraft at or near the airport. Factors that determine the eventual safety of a flight include:

- Push-back from gate
- Movement on aprons, holding bays, de-icing pads, etc.
- Taxi to/from runway
- Visibility conditions
- Pavement configuration
- Lighting, markings, and signs to guide the aircraft to/from the runway
- Other ground traffic
- Runway surface conditions
- Presence of birds or deer
- Available overrun area beyond the ends of the runway
- Pavement structural integrity

In addition, the potential of rejected takeoff and possible rescue efforts is a safety concern associated with every flight. This program area systematically addresses these issues with a single deter-

mination to establish an operational environment that is free of accidents and fatalities.

Customer/Stakeholder Involvement

Airport Technology's major projects support the overall FAA mission of fostering a safe and efficient airport system. Runway traction research directly supports the FAA Challenge 2000 recommendation to develop new technologies and standards for runway friction measurement and safety overrun arrester systems.

Several issues in the Aviation Safety Plan are supported by Airport Technology research. These include preventing runway incursions; improving takeoff and landing performance monitoring; developing environmentally acceptable alternatives for deicing and anti-icing agents; and improving ground navigation technologies, planning, standards, signage, and procedures.

Airport Technology rescue and firefighting research supports an ICAO initiative to replace environmentally harmful Halon 1211 for extinguishing engine fires and other fuel fires.

Aircraft manufacturers and the FAA urgently need new pavement design standards for operating next generation heavy aircraft. Manufacturers need them to assure compatibility of their aircraft on airport surfaces throughout the world. The FAA needs them to assure the public that Federal funds for rebuilding or strengthening runways are being judiciously spent to protect the $100 billion infrastructure investment.

These standards will be developed from data being collected on the National Airport Pavement Test Machine—the first-ever of its kind—over the next 10 years. Both the FAA and the Boeing Company are stakeholders in this important project. Financed through a cooperative R&D agreement between the FAA and the Boeing Company, the design and construction of the Machine has been completed and operation of the facility began in June 1999. Boeing is providing $7 million (one-third of the total cost) towards its completion. The FAA, Boeing, and ICAO will develop pavement design standards for ensuring aircraft-airport compatibility on a worldwide basis.

Accomplishments

During the past five years, the Airport Technology Program has provided products that have enhanced the safety of aircraft operations in the United States and around the world. Research underway, and which will continue into the future, will save the public billions of dollars and protect the environment while attempting to provide an operational environment free of accidents and fatalities.

The Airport Technology Program has provided an engineering solution to aircraft overruns by developing the engineered materials arresting system. The Port Authorities of New York and New Jersey have authorized installation of up to five systems at New York airports at a cost of $4.5 million. The first installation was completed in December 1996 at JFK. The recent overrun of Eagle Saab 340 (May 8, 1999) at JFK and its eventual arrestment and rescue of all 27 passengers and crew of 3 is a prime example of payoff of our research in the engineered materials arresting systems.

The Airport Technology Program has developed a concept for an advanced taxiway system to automatically guide aircraft to and from runways and ramps during low-visibility conditions by controlling taxiway lights and signs without inputs from radar devices. A field demonstration is planned in FY 1999. This system will reduce inadvertent aircraft incursions.

The program has improved pavement marking performance by adding retro-reflective glass beads and silica, which enhances their visibility, durability, and skid resistance.

The program has successfully tested an innovative technology for aircraft deicing using infrared energy. The first installation was completed at Rheinlander airport in Wisconsin. This technology offers potential cost savings over conventional methods.

The program has introduced a new pavement design standard to accommodate the new Boeing 777. The new standard allows the aircraft to operate without weight penalties on existing pavements. Without this standard, hundreds of millions of dollars would have been needed to strengthen U.S. airport pavements.

The program has developed a Driver's Enhanced Vision System to allow airport rescue and fire-fighting vehicles to navigate through fog, rain, sleet, and snow. This technology enables quick and effective response to crash sites. Several airports around the country have adopted this technology for their rescue vehicles.

R&D Partnerships

The Airport Technology Program is committed to working closely with airport operators and experts from all branches of the aviation industry and with existing experts and facilities in the Department of Defense, academia, highway sectors, foreign countries, and the ICAO. The program developed several cost-effective partnerships and agreements, including:

- FAA-U.S. Army Waterways Experiment Station, Interagency Agreement (Pavement)
- FAA-U.S. Army Philadelphia District Office, Interagency Agreement (Pavement)
- FAA-U.S. Air Force, Tyndall Air Force Base, Interagency Agreement (Aircraft Rescue and Fire Fighting)
- FAA-University of Illinois/Northwestern University, Center-of-Excellence for Airport Pavement Research, Partnership through matching funds
- FAA-Boeing Company, Cooperative Research and Development Agreement, Partnership through $7 million influx from Boeing towards the Test Machine
- FAA-Canada (Public Works and Government Services) Project Arrangement for cooperative research in pavement technology
- FAA-NASA Memorandum of Understanding for joint runway traction research

Through these partnerships, research results are published in scientific journals, presented at technical conferences, and discussed at workshops.

Long-Range View

Support for friction testing of new products to eliminate slipperiness as a cause of accidents will continue beyond 2005. Operation of FAA's national pavement test facility began in June 1999 and will continue for ten years. The data collected from the test machine will allow smooth introduction of new heavy aircraft expected to join the fleet well into the next century. The pavement design standards based on these data will:

- Provide assurance to manufacturers about the compatibility of their aircraft with airports throughout the world.
- Provide airport operators precise costs estimates to permit new aircraft operations at their facilities.
- Allow airlines to plan for new equipment and routes.
- Give airport designers confidence in their designs.

This long-range commitment to improving airport technology gives the FAA the tools required to assure the public that Federal funds are being judiciously spent and that public investment in infrastructure is prudently managed.

A05a — Airport Technology

GOALS:

Intended Outcomes: The FAA intends to improve airport system safety, efficiency, and capacity through advancements in aircraft technology and air traffic control systems. The FAA will also develop and maintain standards in all airport system areas to:

- Reduce aircraft accidents due to incursions, particularly in low-visibility conditions.
- Reduce aircraft accidents due to slipperiness caused by ice and snow on runways.
- Reduce environmental impacts due to chemical usage on airports during winter operations.
- Reduce the massive investment required for pavements.
- Improve post-crash rescue and firefighting capabilities.
- Reduce the negative impact of wildlife on airport safety.

Agency Outputs: The FAA is required by law to develop standards and guidance material for airport design, construction, and maintenance. The FAA uses the airport advisory circular (AC) system as its principal means of communicating with a user community consisting of U.S. airport planners, designers, operators, and equipment manufacturers. ACs cover airport geometric design, pavement design, safety areas, visual aids, access roads, rescue and firefighting, ice and snow control, and wildlife control. The FAA and its regional offices enforce standards and guiding material when administering the Airport Improvement Program (AIP).

The Airport Technology program provides the technical information necessary to support and update these agency outputs in a timely manner.

Customer/Stakeholder Involvement: Approximately $2 billion is spent annually to provide operationally safe and reliable airport pavements. The FAA provides about half of this amount as AIP grants; State and local governments and airport operators provide the remainder. Projects funded under the AIP grants must conform to the FAA ACs or standards.

Aircraft manufacturers need new pavement design standards for operation of next-generation heavy aircraft to ensure compatibility of their aircraft with airport surfaces throughout the world. To accomplish this, the FAA and the Boeing Company have entered into a Cooperative Research and Development Agreement (CRDA) to build a unique full-scale pavement test facility at the agency's William J. Hughes Technical Center. The FAA, the Boeing Company, and the International Civil Aviation Organization (ICAO) will use data collected from the project in developing international pavement design standards.

The FAA needs these standards to assure the public that Federal funds for rebuilding or strengthening runways are being judiciously spent and also to protect the $100 billion investment in the U.S. infrastructure.

Accomplishments: During the past five years, the Airport Technology research program has provided products to enhance the safety of aircraft operations in the United States and around the world. Research results are published as FAA ACs and made available to users worldwide. Some major accomplishments are:

- Installed soft-ground arresting systems for stopping aircraft overruns at a major international airport (On May 8, 1999, the arrestor bed installed at John F. Kennedy International Airport, New York, safely stopped a Saab 340 aircraft carrying 27 passengers and 3 crew members, from possibly plunging off the end of the runway into Thurston Bay.)
- Installed prototype advanced taxiway guidance system.
- Developed improved pavement marking for enhancing visibility, durability, and skid resistance.
- Began operations of an aircraft deicing facility using infrared energy at a midsize airport.
- Developed driver's enhanced vision system for firefighting vehicles to navigate in rain, snow, and fog.
- Developed an environmentally acceptable replacement for the chlorofluorocarbon ozone depletor Halon 1211.

- Developed specification for 55-foot elevated boom and aircraft cabin skin-penetration system.
- Issued new pavement design standards to allow operation of Boeing B-777 without weight penalties.
- Established a Center of Excellence (COE) in Airport Pavement Research at the University of Illinois and Northwestern University.
- Installed a comprehensive instrumentation system in concrete pavements at Denver International Airport.
- Established an airport pavement data base containing field data collected at Denver International Airport, allowing on-line access to researchers worldwide.
- Published a technical report, Intermodal Ground Access to Airports: A Planning Guide.

R&D Partnerships:

- FAA-U.S. Army Waterways Experiment Station.*
- FAA-U.S. Army Philadelphia District Office.*
- FAA-U.S. Air Force, Tyndall Air Force Base.*
- FAA-USDA, National Wildlife Research Center, Sandusky, Ohio.*
- FAA-University of Illinois/Northwestern University (COE for Airport Pavement Research).**
- FAA-Boeing Company, Cooperative Research and Development Agreement ($7 million Boeing/$21 million total for National Airport Pavement Test Machine).***
- FAA-Agencies of Canadian Government (for pavement technology and winter operations safety).***
- FAA-NASA (for joint runway traction research).*
- FAA-Port Authorities of New York and New Jersey (for design and construction of aircraft arrestor bed).*
- FAA-industry (to test and develop infrared-deicing facilities and soft-ground arrestor materials).

* Interagency agreement or Memorandum of Agreement

** Partnership through matching funds

** Cost Sharing

Through these partnerships, research results are published in scientific journals, presented at technical conferences, and discussed at workshops.

MAJOR ACTIVITIES AND ANTICIPATED FY 2000 ACCOMPLISHMENTS:

Airport planning and design technology

- Completed data collection for taxiway centerline deviation study at John F. Kennedy International Airport, and began data collection at a second major airport.

Airport pavement technology

- Continued 3-dimensional finite element model (FEM) development: computational efficiency, advanced material models.
- Completed documentation report for layered elastic pavement design program package (LEDFAA).
- Refined failure models for 6-wheel and 4-wheel gear configurations based on analysis of data collected from FAA's National Airport Pavement Test Facility (NAPTF).
- Continued data collection and analysis at Denver International Airport (DIA).
- Published report on 3D finite element model field verification using DIA data.
- Published interim report on National Registry of Airport Pavements.

National Dynamic Airport Pavement Tests

- Completed the first series of full-scale traffic (life) tests at the NAPTF.
- Implemented a database of full-scale test results, allowing on-line access to test data.
- Began analyzing full-scale traffic test data to relate pavement performance to design.
- Reconstructed all pavement test items at the NAPTF and programmed the second series of full-scale traffic tests.
- Continued material testing and evaluation for the NAPTF.

Airport safety technology

- Continued development means to acquire and report runway surface friction values for pilot use.
- Complete evaluation of ramp access to commuter aircraft for people with mobility impairments.
- Completed design of next-generation airport circuitry/components test bed.
- Completed evaluation of light-emitting diode (LED) light strips.
- Completed evaluation of fiber-optic runway-distance-remaining signs at Pittsburgh International Airport.
- Initiated R&D effort aimed at providing warnings to pilots who are approaching/have approached runway holding position.
- Completed study on stability of heavy rescue vehicle and anti-rollover systems.
- Completed development of the full-scale post crash interior fire suppression facility.
- Published testing standards for airport firefighting extinguishing agents.
- Produced a manual on wildlife control methods for airports.
- Completed wildlife habitat study at John F. Kennedy International Airport focusing on grass height and vegetation types.
- Initiated the following studies on wildlife habitats: habitat study in the Pacific Northwest (focusing on vegetation); relocation of raptors at Chicago O'Hare Airport; grass height at USDA Plum Brook Station; habitat study in the southwest.
- Investigated airport wildlife control and detection techniques including use of bird effigies, laser, and microwave as wildlife dispersion methods, and evaluation of Microburst radar for wildlife detection.
- Continued to develop bird strike risk assessment factors for civilian airports.
- Set up comprehensive web site on wildlife mitigation methods and techniques, and continued to populate the National Strike Database.

KEY FY 2001 PRODUCTS AND MILESTONES:

- Conduct the second series of full-scale traffic tests (life tests) at the NAPTF.
- Continue to analyze full-scale traffic test data from NAPTF to relate performance to designs.
- Release updated pavement design program package (LEDFAA 2.0).
- Continue development of three-dimensional finite element based pavement design procedures.
- Continue data collection and analysis at Denver International Airport.
- Complete improvement of back-calculation methods for nondestructive testing of airport pavements.
- Produce report on taxiway centerline deviations of B-747 wide body aircraft.
- Conduct evaluation of improved airport lighting.
- Publish specifications for aircraft infrared deicing system.
- Develop standards for anti-rollover and stability requirements for heavy airport rescue vehicles.
- Develop full scale interior fire suppression facility to perform next generation aircraft requirements research.
- Publish testing standards for airport fire fighting extinguishing agents.
- Continue wildlife habitat studies in the Southwest and Pacific Northwest, at Chicago O'Hare Airport, and at USDA Plum Brook Station.
- Continue evaluation of wildlife dispersion techniques.
- Perform wildlife habitat modeling at selected airports.
- Begin development of the National Advisory Wildlife Strike System for Airports.
- Continue populating the National Strike Database.

FY 2001 PROGRAM REQUEST:

The Airport Technology FY 2001 research program is a collaborative effort among many government organizations, universities, and industry associations. The program funding requested provides the contract support necessary for an integrated, effective research program that delivers

the standards and guidelines for maintaining and enhancing airport infrastructure.

Airport Technology Product and Activities	FY 2001 Request ($000)	Program Schedule					
		FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY2005
Airport Technology	$7,300						
Conduct the Second Series of Full-Scale Traffic Tests (Life Tests)		◆	◇				
Continue to Analyze Full-Scale Traffic Test Data from NAPTF to Relate Performance to Designs		◆	◇				
Release Updated Pavement Design Program Package							
Continue Development of Three-Dimensional Finite Element Based Pavement Design Procedures		◆	◇	◇	◇	◇	◇
Continue Data Collection and Analysis at Denver International Airport		◆	◇	◇	◇	◇	◇
Complete Improvement of Back-Calculation Methods for Non-Destructive Testing of Airport Pavements							
Produce Report on Taxiway Centerline Deviations of B-747 Wide Body Aircraft		◆	◇	◇	◇		
Conduct Evaluation of Improved Airport Lighting		◆		◇	◇	◇	◇
Publish Specifications for Aircraft Infrared Deicing System		◆		◇	◇	◇	
Develop Standards for Anti-Rollover and Stability Requirements for Heavy Airport Rescue Vehicles		◆	◇		◇	◇	◇
Develop Full-Scale Interior Fire Suppression Facility to Perform Next Generation Aircraft Requirements Research		◆		◇			◇
Publish Testing Standards for Airport for Fire Fighting Extinguishing Agents		◆	◇		◇		◇
Continue Populating the National Strike Data Base		◆		◇			
Perform Wildlife Habitat Modeling at Selected Airports		◆	◇		◇		◇
Total Budget Authority	$7,300	**	$7,300	$10,000	$10,500	$11,000	$11,500

Note: Out year numbers are for planning purposes only. Actual funding needs will be determined through the annual budget process.

Budget Authority ($ in Thousands)	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Enacted	FY 2001 Request
Contracts	2,709	2,604	2,703		7,300
Personnel Costs	2,068	1,989	2,016	**	
Other Costs	423	407	281		
Total	5,200	5,000	5,000		7,300

** By Congressional direction, budget line item 1F01 was reduced in FY 2000. The allocation of that reduction is currently under review.

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2.3 Aircraft Safety Program Area Description

Mission

The mission of the Aircraft Safety program is to provide a safe global air transportation system by establishing safety standards and acceptable practices through development of technical information, tools, and technology to ensure safe operation of the civil aircraft fleet.

This program addresses the many hazards that face all aircraft in flight, as well as special hazards that apply to select portions of the civil aircraft fleet. For example, older aircraft are more susceptible to structural problems associated with fatigue and corrosion. New aircraft—with their digital flight control and avionics systems, associated imbedded software, and construction of new non-metallic materials—present significant challenges in certification, continued airworthiness, and operation. However, all aircraft, old or new, must deal with the hazards of adverse weather.

Intended Outcomes

The Aircraft Safety program supports the FAA's safety mission goal: by 2007, reduce U.S. aviation fatal accident rates by 80 percent from 1994-1996 levels.

The Aircraft Safety program focuses on improving system safety through the following research programs:

- Support aging aircraft by developing technologies, procedures, and practices that ensure the continued airworthiness of aircraft structures and aircraft mechanical and electrical systems in the civil fleet.
- Prevent catastrophic failure by developing technologies and methods that will assess the risk and prevent defects, failures, and malfunctions of aircraft, aircraft components, and aircraft systems that could result in catastrophic failure of the aircraft.
- Promote flight safety and reduce the effects of atmospheric hazards by addressing atmospheric hazards in the design, development, and certification process.
- Improve propulsion and fuel systems by enhancing the airworthiness, reliability, and performance of civil turbine and piston engines, their propellers, fuels, and fuel management systems.
- Support fire research and safety by developing near-term fire safety improvements to prevent uncontrollable in-flight fires and increase post-crash fire survival rates and conducting long-range research to develop ultra fire-resistant cabin materials.
- Promote advanced materials and structural safety by ensuring both the safety of U.S. civil aircraft constructed of advanced materials and passenger survival in the event of an accident.
- Enhance aviation safety risk analysis by improving FAA and industry measurement of and accountability for safety performance through risk assessment and operational indicators and sharing safety-related data.

Aircraft safety improvements will reduce fatalities and injuries, reduce hull losses, improve aircraft designs, and impact maintenance and inspection procedures. Potential significant safety benefits include:

- Reduce the approximately 30 to 35 U.S. fire fatalities per year and 135 worldwide, in otherwise survivable accidents. At an estimated savings of $2.7 million per life, saving 24 lives per year would pay for the entire aircraft safety research, engineering, and development effort.
- Use a more reliable airframe inspection technique that has been approved as an alternate inspection technique for detecting corrosion at the juncture of wing and fuselage on DC-9's. The new technique will save over 700 person-hours per inspection, compared to the current inspection method. The technique also requires less disassembly of the aircraft part to conduct the inspection, resulting in less chance for damage during disassembly and reassembly. One airline estimates that by using the new inspection technique, it can save over $2 million over the maintenance cycle for its fleet of DC-9s

Program Area Outputs

The FAA establishes rules for aircraft certification, operation, inspection, maintenance and repair, and publishes advisory circulars to outline acceptable means of meeting the rules. The agency also disseminates technical information in various forms to its airworthiness inspectors and to industry to improve aircraft construction and maintenance practices. Technical information is developed to establish criteria for safety systems, such as seat restraints and protective breathing equipment.

The primary objective is to improve system safety based on elimination of causal factors related to aircraft and flight hazards. Aircraft safety research provides the technical information necessary to support agency outputs.

Aircraft Safety program research customers include aviation manufacturers and aircraft and avionics maintenance facilities, aircraft operators, and the general public who use commercial air transportation. The safety research program supports customer requirements by providing tools that enable demonstration of compliance and development of advisory information to ensure the safety of the flying public. Aviation safety research sponsors are FAA personnel in Flight Standards (AFS) and Aircraft Certification (AIR). The aircraft safety program supports sponsor requirements by providing the research to aid rulemaking and regulation development and by developing technical data and guidance material to develop standards, rules, and regulations.

Program Area Structure

The Aircraft Safety program includes research in a wide range of areas related to aircraft and passenger safety. It focuses on eliminating hazards to the air transportation system, by both preventing accidents from happening and by mitigating the effects of those accidents that do occur. Prevention and mitigation activities include:

- Accident and incident prevention
  - Structural integrity (preventing aircraft structural failure)
  - Propulsion systems (ensuring reliable aircraft power)
  - Flight safety (minimizing operational hazards)
  - Mechanical and electrical system reliability and integrity (reducing aircraft systems failure)
- Accident and incident mitigation
  - Crashworthiness (maximizing crash survivability and escape)
  - Fire safety (preventing fire and fire fatalities)

Customer/Stakeholder Involvement

Research programs within the Aircraft Safety program directly support the Aviation Safety Plan (February 1996) through research supporting priority issues associated with the following workshops: "Safety Data Collection and Use," "Application of Emerging Technologies," and "Aircraft Maintenance Procedures and Inspection."

The Subcommittee on Aircraft Safety, of the FAA Research, Engineering, and Development Advisory Committee, periodically reviews the Aircraft Safety program area. The most recent review was completed in 1999. The program described here is fully responsive to the advice of the subcommittee.

The FAA's primary mission, as originally mandated in Sections 312 and 316 of the Federal Aviation Act of 1958, is to develop, modify, test, and evaluate systems, procedures, facilities, and devices to meet the needs of safe and efficient aviation.

The FAA's research mission was expanded when Congress passed the legislation known as the Aviation Safety Research Act of 1988 (Public Law 100-591). The act mandates that the FAA: "Undertake or supervise research to develop technologies and to conduct data analysis for predicting the effects of aircraft design, maintenance, testing, wear, and fatigue on the life of aircraft and on air safety, to develop methods of analyzing and improving aircraft maintenance technology and practices." The 1988 act also authorized the FAA to generate technology breakthroughs where technology gaps need to be closed while emphasizing the importance of long-range research.

Passage of the Aircraft Catastrophic Failure Prevention program under the Omnibus Reconciliation Act of 1990 (Public Law 101-508) further expanded the FAA research mission. While the

FAA mission originally focused on airplane improvements, the 1990 amendment added proactive research to make airplanes free from catastrophic failure.

In 1998 the FAA published the Aging of Nonstructural Systems Plan in response to the Gore Commission's recommendation. Research is being developed as recommended in that plan.

Safety research will reduce the hazards of operating aircraft, thus providing a higher level of safety. Much of the technology developed will also enhance U.S. aviation industry competitiveness for both manufacturers and operators.

Accomplishments

Research results are disseminated to the agency (aircraft certification and flight standards) and to industry (aircraft manufacturers, operators, and maintainers) as:

- Technical and regulatory guidance for airframe maintenance in the form of handbooks, technical bulletins, aircraft-specific inspection requirements, advisory circulars, and rules.
- Validated instrumentation, procedures, and methodologies for aircraft maintenance, inspection, and repair.
- Reports that provide relevant technical information for aircraft manufacturers, operators, and maintainers.
- Technical data provided to the community at conferences, symposia, workshops, and hardware/software prototype demonstrations.
- Criteria to support certification of aircraft and their safety and emergency equipment.
- Technical data to support regulatory oversight in inspection, maintenance, repair, and standards development.
- Training materials in areas such as damage tolerance requirements, corrosion control, inspection, and maintenance and repair.

Several prototype inspection devices developed tested, and validated in this research program have shown significant potential for more accurate, reliable flaw detection in the airframe and in engines. One method for engine component inspection in particular has shown a four-fold improvement in sensitivity for detecting the type of flaw that led to the 1989 Sioux City accident that killed 211 people.

Numerous advisory circulars (AC) have been developed for a wide range of aviation safety-related activities, including design of composite structures, corrosion control, aircraft deicing, inspection, and repair. ACs controlling aircraft ground deicing for both large transport airplanes (AC 120-58, 9/92) and smaller commuter airplanes (AC 135-17, 12/94) are aimed at ensuring the safe operation of large airplanes and air taxis during icing conditions. These ACs provide guidelines for developing adequate deicing procedures.

Technical data have been developed to support standards development, the certification of aircraft and aircraft components, and the continued airworthiness of aircraft. For example, an enhanced ultrasonic technique has been developed and implemented to detect defects in the titanium billet materials used to manufacture engine rotating components. The system has demonstrated a four-fold improvement in defect detection compared to the current inspection and has detected defects that were missed by the conventional inspection system. Three billets production locations have inspected over 5.5 million pounds of titanium billet using the advanced technique. The new inspection technique will decrease the possibility of engine failure due to undetected flaws and increase the reliability and efficiency of inspection procedures for engine critical components. An industry-wide ultrasonic billet inspection specification based on the new technique was developed and approved by the Society of Automotive Engineers (SAE) Committee K and the SAE Aerospace Council.

R&D Partnerships

Program activities are closely coordinated with related initiatives underway within other government agencies, including the Department of Energy (DOE), DOD, and NASA. Formal agreements of cooperation are in place with the Air Force, Army, Navy, NASA, DOE, and in developing standardization data for materials in MIL-HDBKS 5 and 17.

International agreements are in place with government agencies and research laboratories in the

United Kingdom, the Netherlands, France, Italy, Australia, Canada, and Russia.

Numerous grants are in place with universities and research laboratories to leverage their interests and capabilities. Partnerships have been established with academia and industry through consortia and centers of excellence. For example, the Airworthiness Assurance Center of Excellence (AA-COE) was established in September 1997 to conduct research in the areas of:

- Maintenance, inspection, and repair
- Crashworthiness
- Propulsions and fuel systems safety technologies
- Advanced materials

The AA-COE consists of 9 core members, 90 industry partners, 45 university affiliates, and 7 other partners, including other Government laboratories and state organizations. The COE provides matching funds, which solidify a significant COE-FAA partnership. Through this partnership, the Government, academic institutions, and industry leverage the resources available for aviation research.

Technology Transfer

Technology transfer occurs through a variety of mechanisms:

- Technical reports documenting research results.
- Conferences on a wide range of subjects designed to disseminate technical information.
- Technical organizations, such as the American Society on Testing and Materials (ASTM), Society of Automotive Engineers (SAE), and American Institute of Aeronautics and Astronautics (AIAA), that use study committees to ensure the transition of research results to standards, guidelines, etc.
- Hardware and software prototype demonstrations and technology workshops.
- The FAA Airworthiness Assurance Nondestructive Inspection Validation Center (AANC) demonstrations and validations of cost-effective aircraft inspection equipment and techniques to industry.

Long-Range View

The need for safety and safety-related research will continue indefinitely. With the emergence of new and advanced technologies, there will be an ongoing need to improve air transportation system safety. There will always be a need to understand the impact of new technology on operator performance. As air traffic continues to increase, and as aircraft continue to age, there will always be a need to address issues related to aging aircraft.

With new technology, new damage mechanisms may occur, introducing hazards that must be understood and addressed. Research in aircraft safety must be continued to understand the impact of changes in technology on current regulatory safety standards, certification procedures, and acceptable practices for demonstration of compliance mandates.

- Hardware and software prototype demonstrations and technology workshops
- The FAA Aging Aircraft Nondestructive Inspection Validation Center (AANC) demonstrations and validations of cost-effective aircraft inspection equipment and techniques to industry

Long-Range View

The need for safety and safety-related research will continue indefinitely. With the emergence of new and advanced technologies, there will be an ongoing need to improve air transportation system safety. There will always be a need to understand the impact of new technology on operator performance. As air traffic continues to increase, and as aircraft continue to age, there will always be a need to address issues related to aging aircraft.

With new technology, new damage mechanisms may occur, introducing hazards that must be understood and addressed. Similarly, medical advances in diagnosis and treatment force a continuing examination of crew or passenger limitations in existing and future aircraft. Research in aircraft safety must be continued to understand the impact of changes in technology on current regulatory safety standards, certification procedures, and acceptable practices for demonstration of compliance mandates.

A06a Fire Research and Safety

GOALS:

Intended Outcomes: The FAA intends to improve system safety by developing technologies, procedures, test methods, and criteria for preventing accidents caused by in-flight fires and fuel tank explosions and eliminating burning cabin materials as a factor in post-crash fire survivability. The fire research and safety program focuses principally on:

- Long-term research to develop new interior materials that meet fire resistance criteria mandated in the Aviation Safety Research Act of 1988.
- Near-term improvements in aircraft fuel tank explosion protection, fire detection and suppression systems and interior materials fire test methods and criteria.

Agency Outputs: The FAA establishes rules for aircraft fire safety in terms of material selection, design criteria, and operational procedures. The agency also provides advisory material on methods of compliance with fire safety regulations and guidelines. The fire research and safety program is the major source of technical information used to develop this regulatory material. Additionally, the program provides industry with new safety products developed through long-term applied research. These products are typically embodied in new materials and formulations, new test methods, government-owned patents, reports, and journal publications.

Customer/Stakeholder Involvement: The FAA has broad industry and government participation in each aspect of the fire research and safety program.

- The Aircraft Safety Subcommittee of the FAA Research, Engineering and Development Advisory Committee has repeatedly endorsed the fire research and safety program and placed high priority on its activities.
- Long-term research in fire resistant materials is required by specific language in the Aviation Safety Research Act of 1988 and is directly supported by the aircraft industry and materials producers through university-based FAA research consortia.
- The FAA will soon create an Aviation Rulemaking Advisory Committee (ARAC) on fuel tank inerting to recommend viable methods of fuel tank protection. This industry working group will impact related research undertaken by the FAA.
- The aircraft manufacturers and airlines have a need to evaluate halon replacement agents and improve interior material fire tests. Recognizing the FAA's unique capabilities in fire safety, the aviation industry actively participates in separate working groups headed by the FAA to develop approval standards for halon replacements and improved material fire tests. Foreign airworthiness authorities are active participants, as well, to ensure harmonization of outputs.
- The National Transportation Safety Board (NTSB) relies heavily on program personnel for on-site accident investigation such as the recent Swissair MD-11 and American Airlines MD-80 accidents.

Accomplishments: Results of fire research and safety were provided to FAA certification and inspection personnel for use in fire safety regulations and advisory material, approval of regulatory fire test procedures, and approval of aircraft fire protection installations. Recent program accomplishments include:

- Developed thermal acoustical insulation fire test criteria that were the basis for a major Notice of Planned Rulemaking (NPRM) planned for issuance in late 1999.
- Developed performance standards for gaseous halon replacement agents used in cargo compartment fire suppression systems and cabin hand-held extinguishers.
- Published technical report describing tests demonstrating the extreme fire hazards of chemical oxygen generators activated in proximity to combustible materials.
- Published technical report demonstrating the difficulties met by flight attendants attempting to extinguish fires in accessible cargo compartments.

- Published a technical report evaluating the effectiveness of cargo extinguishing systems against oxygen enhanced fires.
- Scaled-up benzoxazine chemistry through industrial consortium.
- Demonstrated a decorative panel with 60% reduction in heat release rate per FAR 25.853.
- Demonstrated optimized design, theory and operation of microscale heat release rate calorimeter (Patent awarded).
- Published four journal articles, one technical report and 10 conference proceedings on heat release rate of fire resistant materials.
- Formed partnership with Boeing, Schneller Inc., Ciba Specialty Chemicals, and the University of Massachusetts to scale-up and evaluate chloral polymers for aircraft interior applications.

In addition, approximately two dozen reports and published papers are generated yearly from the in-house activity. Fire test laboratories are used annually to train FAA certification engineers, and program personnel participate in approximately three major accident investigations yearly at the request of the NTSB. The FAA operates the most extensive aircraft fire test facilities in the world.

R&D Partnerships: The FAA sponsors an international halon replacement working group. This group collaborates in research and development leading to alternate agent selection for aircraft applications as well as test methods and criteria. The FAA also sponsors an international aircraft materials fire test working group. This group strives to improve material fire tests standardization, such as engaging in round robin testing to ensure that the lab-to-lab variation in results is acceptably small. The FAA organized an interagency working group on fire and materials to provide a vehicle for technology exchange among U.S. Government agencies and to prevent unwarranted duplication of work. The FAA has interagency agreements with the U.S. Air Force and the National Institute of Standards and Technology for common interest research. The agency has a memorandum of cooperation with the British Civil Aviation Administration (CAA) for a variety of fire safety research efforts and separate letters of cooperation with Canadian, Japanese, and European aviation authorities. The fire research and safety program also has grant programs with many educational institutes. Several Fortune 100 companies share costs of developing new fire resistant materials at university-based FAA research consortia.

MAJOR ACTIVITIES AND ANTICIPATED FY 2000 ACCOMPLISHMENTS:

Fire Resistant Materials

- Commercialized FAA microscale heat release rate calorimeter.
- Made available user-friendly computer code for predicting material flammability.
- Demonstrated molded thermoplastic for cabin parts with 50% reduction in heat release rate.

Fire Detection and Suppression

- Developed a performance standard for gaseous halon replacement agents in engine fire extinguishing systems.
- Developed smoke/fire simulants for use in cargo detector approval testing.
- Completed full-scale effectiveness testing of cargo compartment water mist system.
- Determined cost and evaluated performance of a prototype airport ground-based fuel tank inerting system.
- Initiated development of an airborne fuel tank inerting system.

Fire Safety Design

- Completed laboratory round robin studies of new fire test criteria developed for thermal acoustical insulation.
- Evaluated explosive hazards related to fuel tank heating/cooling and localized hot surfaces.
- Designed and constructed a full-scale fuselage test article for characterizing fire hazards in new double-decked Very Large Transport Aircraft (VLTA).
- Publish Upgraded Material Fire Test Handbook.

KEY FY 2001 PRODUCTS AND MILESTONES:

Fire Resistant Materials

- Scale-up chloral polymers for evaluation in production panels and molded parts.
- Make available computational models of polymer combustion.
- Link heat release database to National Institute of Standards and Technology fire web site.
- Fire Detection and Suppression
- Draft a revised Advisory Circular (AC) for approval testing of cargo smoke detectors.
- Design, fabricate and install a fuel tank inerting system on a flight test aircraft.
- Determined Fuel Tank Explosive Hazards.

Fire Safety Design

- Characterize cabin and fuselage fires in VLTA under full-scale fire tests conditions.
- Initiate study of aircraft hull losses and fatalities caused by oxygen system malfunction or damage.

FY 2001 PROGRAM REQUEST:

In FY 2001, long range research on ultra-fire resistant aircraft interior materials will focus on synthesizing and evaluating the heat release rate of an entire class of promising polymers based on chlorobisphenol monomer. Near term fire safety improvements will focus on fuel tank explosion protection, fire management, and new double-decked transport aircraft. Utilizing prior year test results, an airborne fuel tank inerting system will be designed and fabricated in FY 2001 for flight testing in FY 2002. A multi-year effort to develop standardized testing procedures for the approval of cargo detectors will culminate in a revised Advisory Circular. To support possible new fire safety standards for double-decked VLTA, the characteristics of cabin and fuselage fires will be measured under full-scale test conditions. Finally, work will commence related to fixed oxygen system fire safety by initiating a study to document and analyze past aircraft fire fatalities and hull losses caused by oxygen system failures.

A06a - Fire Research and Safety Product and Activities	FY 2001 Request ($000)	Program Schedule					
		FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY2005
061-110 Fire Research and Safety							
Fire Safety Design	$727						
Completed Laboratory Round Robin Studies		◆					
Designed and Constructed a Full-Scale Fuselage Test Article		◆					
Publish Upgraded Material Fire Test Handbook		◆				◇	
Initiate Study of Aircraft Hull Losses and Fatalities Caused by Oxygen System Malfunction or Damage			◇				
Draft Oxygen Systems Safety Advisory Circular (AC)						◇	
Characterize Cabin and Fuselage Fires in Very Large Transport Aircraft (VLTA)			◇				
Define VLTA Fire Protection Methodology							◇
Fire Resistant Materials	$1,005						
Demonstrated Thermoplastic for Molded Parts with 50% Reduction in Heat Release Rate		◆					
Commercialized FAA Microscale Heat Release Rate Calimeter		◆					
Scale-Up Chloral Polymers for Evaluation			◇				
Demonstrate Seat Cushion with 50% Reduction in Heat Release Rate				◇			
Link Heat Release Date to National Institute of Standards and Technology (NIST)			◇				
Demonstrate Cost Effective Low Heat Release Materials						◇	
Fire Detection and Suppression	$650						
Completed Cargo Compartment Water Mist Fire Suppression System Evaluation		◆					
Determined Fuel Tank Explosion Hazards		◆					
Determined Cost/Performance of Prototype Airport Ground-Based Inerting System		◆					
Design and Install an Airborne Fuel tank Inerting System			◇				
Flight Test Fuel Tank Inerting System				◇			
Assess Oxygen/Nitrogen Separation Membrane Technology				◇			
Developed a Performance Standard for Gaseous Halon Replacement Agents		◆					
Complete Full-Scale Test Evaluation of Solid Propellant Gas Generator Technology			◇				
Revise Draft Advisory Circular for Smoke/Fire Detection			◇				
Develop Criteria for Approval of Reduced False-Alarm Smoke/ Fire Detector Designs				◇			
Personnel and Other Costs	$3,069						
Total Budget Authority	$5,451	$4,750	$5,451	$5,635	$5,845	$6,081	$6,342

Note: Out year numbers are for planning purposes only. Actual funding needs will be determined through the annual budget process.

Budget Authority ($ in Thousands)	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Enacted	FY 2001 Request
Contracts	2,963	3,377	2,098	1,292	2,382
Personnel Costs	3,345	3,001	2,315	3.116	2,856
Other Costs	685	615	337	342	213
Total	6,993	6,993	4,750	4,750	5,451

A06b Advanced Materials/Structural Safety

GOALS:

Intended Outcomes: The FAA intends to ensure the safety of U.S. and foreign-made civil aircraft constructed of advanced materials as well as to improve passenger survival in the event of an accident. The study of advanced materials focuses on the following technical areas:

- Standardized analysis and test methods for worldwide harmonization.
- Better understanding of effects of repeated loads, damage, and joint configurations on remaining strength and life of composite aircraft structure.
- Reliability methods, as they apply to the design of composite aircraft components, and criteria for acceptable risk.

The study of structural safety focuses on the following technical areas:

- Enhanced occupant survivability and reduced personal injury in the event of an accident.
- Improved crash characteristics of aircraft structures, cabin interiors, auxiliary fuel tank systems, and occupant seat/restraint systems.
- Improved analytical and modeling capabilities to develop understanding of aircraft crash events to lead to more efficient certification.

Agency Outputs: The FAA establishes rules for aircraft certification and operation and publishes Advisory Circulars (AC) to provide acceptable means of achieving compliance with those rules. While the rules are the same for composite or metal structure, the means of compliance reflect behavioral differences in the structural materials. AC 20-107A, "Composite Structure" has been published, but advances in technologies and materials lead to periodic updates and expansion of the AC. Technical information is disseminated to regulatory personnel through technical reports, handbooks, and guidance by the FAA National Resource Specialist. The goal is to develop pertinent data, so that the regulatory processes keep pace with industry advances, including state-of-the-art test and evaluation for state-of-the-art technology and design. The advanced materials/ structural safety program provides support in rulemaking and the development of guidance material for industry compliance. In structural safety, the FAA revises or updates Federal Aviation Regulations to accommodate new information for overhead stowage bins, auxiliary fuel tanks, and seat/restraint systems.

Customer/Stakeholder Involvement: The FAA has demonstrated the need for the advanced materials/ structural safety program through consensus building activities including:

- The Aviation Rulemaking Advisory Committee (ARAC) is a FAA/industry forum established to ensure that agency rulemaking is effective in achieving intended results. ARAC is also effective in identifying requirements and priorities for supporting R&D activities.
- The Challenge 2000 report concludes that the FAA should enhance its already effective program of gathering data and improving the certification of composite structures.
- A recent National Research Council report highlights the needs related to advanced materials and urges the FAA to step up advanced materials research for aircraft community benefits.
- The 1994 DOT Strategic Plan established Goal 3.3, "support the use of advanced materials in manufacturing and constructing transportation facilities and equipment."
- The advanced materials/structural safety program is responsive to Public Law 100-591, Aviation Safety Research Act of 1988, and House of Representatives Report 100-894, to develop technologies, to conduct data analysis for current aircraft, and to anticipate problems of future aircraft.

Accomplishments: Results of this program are provided to aircraft manufacturers, maintainers, and operators in the form of technical reports, handbooks, ACs, and guidance in the process of certification.

In the advanced materials area, the program has updated or issued two ACs and four handbooks, published more than 50 technical reports, articles, and papers, and has cosponsored three technical conferences with attendance of approximately 1,200 experts. A three volume report on test methods for composites was disseminated to industry and government to provide an authoritative

compendium on state-of-the-art composites testing with recommendations for usage and identified gaps. An alternative method of compliance to demonstrate repeated load life was developed and now significantly reduces fatigue testing time to ensure required service life. This method has been used successfully in the certification process of many aircraft components (recent example, the General Electric 90 fan blades) and has been adopted as a worldwide practice.

In the structural safety area, six reports on in-house commuter crash testing, as well as reports on aircraft ditching and aircraft flotation, have been widely disseminated. Rulemaking has been proposed for commuter seat/restraint systems. Also, in-service overhead stowage bins have been made more resilient to crash impact. A workshop on a crash impact modeling code developed by the FAA was held for certification engineers and industry participants.

R&D Partnerships: In the advanced materials area, the FAA coordinates with NASA to leverage research expenditures. The FAA concentrates on safety and certification issues, including testing, while NASA has the lead in analysis and design issues. Currently, the FAA supports NASA's efforts to develop a composite property database for General Aviation (GA) aircraft under the NASA Advanced GA Transport Experiments (AGATE)/Integrated Design and Manufacturing (IDM) Program. The FAA has also initiated a partnership with the Rotorcraft Industry Technology Association (RITA) to share in rotorcraft composite materials research.

The FAA cosponsors, with the U.S. Army, MIL-HDBK-17, a primary and authoritative source for statistically based characterization data of current and emerging composite materials. This international reference reflects the best available data and technology for testing and analysis, and includes data development and usage guidelines. The handbook is used by FAA officials as a primary supporting document in structural substantiation in the certification process. On recommendations by the ARAC committee, material data contained in this handbook will be acceptable for use in the certification process. In the structural safety area, there are agreements for cooperative programs with the National Highway Traffic Safety Administration (NHTSA), with the U.S. Army and Navy, and with NASA Langley Research Center.

There has been coordination with the French and Italian Governments through memoranda of cooperation and an exchange of personnel in the crash testing area. A cooperative research program in the development of crash modeling software tools is underway with the United Kingdom. The program has also worked closely with Wichita State University to develop crash dynamic models and experimental energy absorbing seats.

The structural safety area has established working relationships with airframe manufacturers such as Boeing and Raytheon and with manufacturers of overhead bins and auxiliary fuel tanks. The advanced materials and structural safety areas are benefiting from a close working relationship with the Airworthiness Assurance Center of Excellence. The research performed under this program is leveraged by the monetary and intellectual contributions of its core universities.

MAJOR ACTIVITIES AND ANTICIPATED FY 2000 ACCOMPLISHMENTS:

Advanced Materials

- Completed research on damage accumulation in composites due to repeated loads. This aids in developing certification criteria for composite structural components.
- Established methodology to predict delamination initiation and growth at critical details in composite structures.
- Provided database for support to AGATE/IDM on effects of bond thickness on structural performance of small composite aircraft.
- Developed new thermal analysis model for composite aircraft.
- Initiated new start to address certification issues of composite materials pertaining to rotorcraft.

Structural Safety

- Completed vertical drop test of a B737 fuselage section with overhead bins to determine their behavior under a survivable crash scenario.

- Completed aircraft crash modeling tool for accident investigators.
- Initiated research on the effect of side facing seating on occupant protection criteria and restraint systems.

KEY FY 2001 PRODUCTS AND MILESTONES:

Advanced Materials

- Generate a database for durability of textile forms and stitching as manufactured by resin transfer molding.
- Establish criteria to assure damage tolerance of composite sandwich structures for small aircraft and rotorcraft.

Structural Safety

- Complete assessment of the crash resistance of current rotorcraft, commuter, and transport fuel systems.
- Establish guidelines for conducting Head Injury Criteria (HIC) component testing to supplement full scale testing.
- Publish data on behavior of transport aircraft overhead storage bins in a severe but survivable crash.
- Complete ditching research in conjunction with the Navy.

FY 2001 PROGRAM REQUEST:

In FY 2001, the program continues to focus on the areas listed at the beginning of the GOALS section above. Specific areas are damage tolerance of sandwich structures applicable to current and future aircraft fuselages, durability of textiles, and developing a database on effects of bond thickness on structural performance of small bonded composite aircraft. In addition, work will continue to develop data applicable to rotorcraft. Within the structural safety area, a unified analytical modeling capability will be under development in order to reduce costly testing. The models will include the response of seats, restraint systems, seat attachments, and airframes under dynamic crash conditions. Other areas of research to be continued are crash resistance of fuel systems, determination of loads in rotorcraft ditching, and development of component tester for HIC compliance. A drop test of a representative rotorcraft to determine dynamic loads will also be conducted in future years.

A06b - Advanced Materials/Structural Safety Product and Activities	FY 2001 Request ($000)	Program Schedule					
		FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY2005
062-111 Advanced Materials Structures							
Advanced Materials	$978						
Established Methodology to Predict Delamination Initiation		◆					
Established Data Base on Effects of Bond Thickness		◆					
Generate Data Base for Durability of Textile Forms			◇				
Establish Criteria for Damage Tolerance of Sandwich Structures			◇				
Establish Rules for Replacing Metal Rotorcraft Parts with Composites			◇				
Establish Guidelines for Probabilistic Design Certification				◇			
Develop Data Base on Verified Design Practice for Adhesive Joints				◇			
Develop Data Base on Damage Tolerance of Sandwich Structure					◇		
Develop Durability and Damage Tolerance Data for Rotorcraft					◇		
Identify Data for Certification of Materials at Elevated Temperatures						◇	
Develop Certification Methodology for New Materials and Forms						◇	
Develop Certification Methodology for High Cycle Fatigue							◇
062-110 Structural Safety							
Structural Safety	$822						
Completed Vertical Drop Test of B737 Fuselage Section with Stowage Bins		◆					
Completed Aircraft Crash Modeling Tool for Accident Investigators		◆					
Establish Guidelines for Conducting Head Injury Criteria (HIC) Component Testing			◇				
Complete Assessment of the Crash Resistance of Transport Fuel Systems			◇				
Complete Rotorcraft Ditching Research in Conjunction with the Navy			◇				
Publish Data on Crash Resistance of Transport Aircraft Stowage Bins			◇				
Develop Analytical Capability to Model Aircraft Crash Events				◇			
Identify Transport Ditching Requirements				◇			
Define Rotorcraft Crash Pulse					◇		
Define New Occupant Injury Criteria					◇		
Establish Crash Test Data Base						◇	
Validate Water Impact Model						◇	
Develop Occupant Protection Criteria for Side Seating							◇
Personnel and Other Costs	$997						
Total Budget Authority	**$2,797**	**$2,338**	**$2,797**	**$2,866**	**$2,948**	**$3,046**	**$3,162**

Note: Out year numbers are for planning purposes only. Actual funding needs will be determined through the annual budget process.

Budget Authority ($ in Thousands)	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Enacted	FY 2001 Request
Contracts	1,249	2,059	809	1,089	1,800
Personnel Costs	1,507	835	803	1,109	937
Other Costs	309	171	122	140	60
Total	**3,065**	**3,065**	**1,734**	**2,338**	**2,797**

A06c Propulsion and Fuel Systems

GOALS:

Intended Outcomes: The FAA intends to improve system safety by enhancing the airworthiness, reliability, and performance of civil turbine and piston engines, their propellers, fuels, and fuel management systems. The major outcomes from this program include:

- Continued reliability and safety of general aviation operations by providing a safe transition to a new high octane unleaded aviation gasoline.
- A reduction in the number of intrinsic turbine rotor failures by improved and standardized design and life management procedures.
- Improved melt processes for premium quality titanium alloys used for turbine rotor components.
- Improved manufacturing and quality practices to eliminate manufacturing induced anomalies in turbine rotor components.
- Reduced turbine engine failure/downtime and improved maintenance efficiency through advanced monitoring/diagnostic hardware and software.
- Minimized probability of in-flight fuel tank explosions.
- Continued reliability and safe use of Jet A fuel containing red dye contamination.

Agency Outputs: The FAA maintains the airworthiness of aircraft engines, fuels, and airframe fuel management systems by issuing certification and advisory standards, and by supporting technical society specifications and recommended practices. The FAA also publishes technical information in various forms in the public domain. Technology may also be provided to the industry through hardware and software prototype demonstrations and technology workshops or various training medium. This research program provides the resources and oversight to deliver the necessary propulsion, fuel, and fuel transfer system technology in support of these agency outputs.

Customer/Stakeholder Involvement:

- The FAA collaborates with the engine industry to identify and implement cost effective safety improvements that address incidents and accidents caused by in-service engine failures. This collaboration was initiated by the FAA Titanium Rotating Components Review Team. This team advises on the adequacy of industry standards and procedures to ensure the safety of the titanium alloy high energy rotating components of turbine engines. Industry participation is through working committees under the Aerospace Industries Association (AIA), including the Materials and Structures Committee, Rotor Integrity Subcommittee, Rotor Manufacturing Subcommittee and the Jet Engine Titanium Quality Committee.
- The AIA committees identify potential improvements in manufacturing process control, manufacturing and in-service inspection, and design and life management of failure critical rotating engine parts. These improvements are the basis for identifying specific R&D already underway or planned for this program.
- The FAA participates and provides leadership in testing capability for the Coordinating Research Council (CRC) Unleaded Aviation Gasoline Development Group. This group was formed in February 1995 to oversee research and testing for the development of the next generation of high octane unleaded aviation gasoline. EPA regulations and the Clean Air Act of 1990 mandate removal of lead from all gasoline. The critical need for the development of this fuel is reflected by the list of participants on the CRC group. Active participants and members of this group include: most major oil companies (U.S. and worldwide); general aviation airframe and engine manufacturers; general aviation user groups such as the Aircraft Owners and Pilots Association (AOPA), Experimental Aircraft Association (EAA), and General Aviation Manufacturers Association (GAMA); the research sponsor, the FAA New England Region Engine and Propeller Directorate; and the FAA Small Airplane Directorate in Central Region.
- The FAA sponsored Technical Oversight Group On Aging Aircraft (TOGAA) reviews

technical aspects of the airworthiness assurance R&D activities. TOGAA has provided feedback on the progress of the turbine engine program over the last three years.

- The Subcommittee on Aircraft Safety of the FAA Research, Engineering and Development Advisory Committee was briefed on the propulsion program, an initiative which the subcommittee strongly supports.
- The FAA/industry initiative on turbine engine rotor integrity research in this program addresses National Transportation Safety Board (NTSB) recommendations A-90-89 and A-90-90.
- The program addresses recommendations of the FAA Titanium Rotating Components Review Team Report, which was presented to industry in a public meeting held in May of 1991.
- The program supports recommendations by the Aviation Rulemaking Advisory Committee (ARAC) Fuel Tank Harmonization Working Group.

The Aerospace Industries Association convened an ad hoc group to study the effects of red dye contamination of Jet A fuel and to identify solutions to this problem. This effort has resulted in a program funded by the FAA, Defense Energy Support Center, Internal Revenue Service (IRS), Air Transport Association, and engine and airframe manufacturers. Additional funding from the oil refiners may be forthcoming.

Accomplishments: Results of the propulsion and fuels research program provided to engine and aircraft regulatory and industry stakeholders:

- Drafted an advisory circular on the correlation, operation, design, and modification of turbofan/jet engine test cells, which provide guidance on the testing of aircraft engines.
- Completed a training video production entitled; "Aircraft Turbine Engine Test Cell Correlation."
- Hosted and sponsored four annual joint FAA/Air Force public workshops with published proceedings on the application of probabilistic design methodology to gas turbine rotating components.
- Demonstrated integrated probabilistic rotor design and life management code (DARWIN version 3.2) for titanium alloys to provide commercial aircraft turbine engine manufacturers a tool to augment their current "safe life" management philosophy approach.
- Conducted DARWIN Code version 3.2 FAA/Industry training workshop.
- Demonstrated and delivered the defect deformation micro code for analysis of titanium alloy defects during the turbine disk forging process.
- Determined the fleet octane requirement to be the single most critical parameter for development of high octane unleaded aviation gasoline.
- Completed validation of ground based procedures for determining octane requirements to be used in the development of a new high octane unleaded aviation gasoline.
- Participated in establishing matrix components to be used in developing candidate fuel formulations.
- Initiated engine tests on an industry-supplied fuel formulation.
- Completed report on engine octane requirements.
- Determined and defined detonation detection procedures for proposed ASTM method to test unleaded replacement fuel(s).
- Issued final determination of fleet octane requirements for unleaded replacement in high fuel performance piston engines to be greater than 100 octane.
- Completed draft final report on in service Jet A fuel sample analysis volatility survey.

R&D Partnerships:

A cooperative grant was awarded to the Southwest Research Institute, which has teamed with major engine manufacturers Pratt and Whitney, General Electric, Honeywell (Allied-Signal), and Rolls Royce-Allison. This work develops probabilistic-based turbine rotor material design and life management tools for improved rotor integrity. This work is closely coordinated with the U.S. Air Force Wright Laboratory, which conducts complementary

research, and with ongoing research activities of the FAA Engine Titanium Consortium sponsored under budget item A06e, Aging Aircraft. The FAA transfers the completed probabilistic engine design code versions for use by the industry via training workshops.

- The partnership exhibited by the CRC Unleaded Aviation Gasoline Development Group provides an arena to conduct research that is unprecedented in the aviation gasoline industry. The proprietary and competitive forces inhibiting progress, in the high octane aviation gasoline development, have been set aside. This allows the transfer of technology to and from government and industry to benefit all participants. Industry participants include Texaco, Exxon, Phillips Petroleum, Chevron, British Petroleum, Cessna, Raytheon (Beech), Teledyne Continental, and Textron Lycoming.
- A FAA contract with the Southwest Research Institute will determine an acceptable level of fuel dye contamination, which allows continuous safe turbine engine operation. The following organizations contribute funding to this effort: the FAA, Defense Energy Support Center, IRS, Air Transport Association, American Petroleum Institute, General Electric, Pratt & Whitney, Rolls Royce, Honeywell (AlliedSignal) and Boeing.
- The program is benefiting from a close working relationship with the Airworthiness Assurance Center of Excellence. The research performed under this program is leveraged by the monetary and intellectual contributions of its core universities.

MAJOR ACTIVITIES AND ANTICIPATED FY 2000 ACCOMPLISHMENTS:

- Completed draft report on the results of titanium melting enhancements.
- Continued laboratory characterization of industry supplied preliminary candidate fuels.
- Continued engine ground testing of industry supplied preliminary candidate unleaded fuels.
- Began characterization and testing of industry supplied candidate fuels using FAA engine ground test facilities.

KEY FY 2001 PRODUCTS AND MILESTONES:

- Commercialize the DARWIN rotor design and life management code.
- Complete validation of the DARWIN rotor design and life management code.
- Complete spin pit tests of disks that contain hard alpha defects to validate the FLIGHT_LIFE fracture mechanics module in DARWIN.
- Complete vacuum fatigue crack growth tests on nickel alloys.
- Publish report that defines an acceptable concentration of red dye contamination in Jet A fuel for continuous engine operation.
- Commence flight tests on industry supplied candidate unleaded fuels.

FY 2001 PROGRAM REQUEST:

In FY 2001, the program continues development of a probabilistically based turbine engine rotor design code with damage tolerance assessment. This code will be a life and risk management tool to augment the current "safe life" design approach for integration into engine manufacturer rotor design procedures. The application of this tool, as a FAA approved design certification standard, is intended to improve turbine rotor structural integrity while reducing the risk of failure.

The program also continues research on industry provided lead free fuel formulation candidates to replace the low lead aviation gasoline (ASTM D910 100LL) currently in use. These tests evaluate new fuel formulation effects on engine detonation, material compatibility, volatility, engine performance, storage stability, water reaction, emissions, fuel consumption and engine durability. In FY2001 fuel tests using the FAA flight test aircraft will begin. All parameters impact on safe engine operation and all data supports eventual certification of a replacement fuel.

The program continues to develop rotor disk alloy material melt processes to establish commercial manufacturing standards that will eliminate metallurgical defects to produce premium quality, rotor grade alloy materials. Commercial aircraft accident history has shown that the presence of these defects in rotor disks have been the initiat-

ing cause of uncontained rotor failures. These failures are a major contributor associated with the engine failure fatal accident rate.

In FY 2001, the program will initiate R&D support of the AIA Rotor Manufacturing Subcommittee to develop advanced manufacturing technologies. The purpose of this activity is to qualify and control the final surface manufacturing processes that could have an impact on rotor disk fatigue life.

The FY 2001 program continues research to establish an improved understanding of the metallurgical factors that shorten fatigue life in titanium rotor disk alloys. The microstructure-based modeling capability developed by this activity will enable more accurate prediction of the risk of serious engine caused accidents.

A06c - Propulsion and Fuel Systems Product and Activities	FY 2001 Request ($000)	Program Schedule					
		FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY2005
063-110 Propulsion and Fuel Systems Research							
Turbine Engine Research	$3,150						
Validate the Probabilistic Rotor Design and Life Management Code (DARWIN)			◇				
Commercialize Darwin Code			◇				
Demonstrate Probabilistic Integration Design Code – Surface Flaws				◇			
Deliver Probabilistic Rotor Design Code – Nickel Alloys					◇		
Reported on Results of Titanium Melting Enhancements		◆					
Verify Hearth Melt Process Models				◇			
Demonstrate the On-line Monitoring for Alloy Composition Control in a Commercial Electron Beam Melt Furnace						◇	
Develop Equations for Finite Element Modeling of Cold Dwell Fatigue					◇		
Develop Computer Model for Cold Dwell Fatigue Damage Evolution and Failure in Titanium							◇
Unleaded Fuels and Fuel System Safety Research	$862						
Continued Laboratory Characterization of Industry Supplied Candidate Fuels		◆					
Continued Engine Ground Testing of Industry Supplied Candidate Unleaded Fuels		◆					
Complete Determination of Acceptable Concentration of Red Dye Contamination in Jet A Fuel for Continuous Engine Operation			◇				
Begin Flight Tests on Industry Supplied Candidate Fuels			◇				
Complete Draft Specification for High Octane Unleaded Aviation Gasoline				◇			
Begin Fleet Evaluation of Candidate Unleaded Aviation Gasoline				◇			
Personnel and Other Costs	$1,188						
Total Budget Authority	**$5,200**	**$3,126**	**$5,200**	**$5,296**	**$5,423**	**$5,580**	**$5,770**

Note: Out year numbers are for planning purposes only. Actual funding needs will be determined through the annual budget process.

Budget Authority ($ in Thousands)	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Enacted	FY 2001 Request
Contracts	1,566	3,643	1,761	1,754	4,012
Personnel Costs	1,522	1,126	932	1,230	1,114
Other Costs	312	231	138	142	74
Total	**3,400**	**5,000**	**2,831**	**3,126**	**5,200**

A06d Flight Safety/Atmospheric Hazards Research

GOALS:

Intended Outcomes: The FAA intends to improve aircraft safety by developing technologies, technical information, procedures, and practices. These measures help ensure safe operation of the civil fleet in icing conditions and in the electromagnetic environment, and address safety issues pertaining to software, digital flight controls and avionics systems.

In the area of aircraft icing, the program focuses on establishing operating rules and procedures for deicing and anti-icing to ensure a clean aircraft at takeoff. It also focuses on developing technology to determine the existence of frozen contamination and the failure of anti-icing fluids on critical aircraft surfaces. It addresses characterization of the atmospheric icing environment by collecting and analyzing supercooled cloud and precipitation data. It also develops technology (ice protection and detection), certification requirements, and advisory material to ensure that aircraft meet performance, stability, and control safety standards during or after in-flight operation in icing conditions.

The electromagnetic hazards to aircraft systems program focuses on protecting aircraft electrical and electronic systems against the effects of lightning and High Intensity Radiated Fields (HIRF). HIRF effects may come from airborne, shipborne and ground based emitters, and from portable electronic devices, i.e., tape players, laptop computers, cellular phones, etc.

The software and digital systems safety program addresses aircraft safety and certification issues. These issues involve the use of emerging, highly complex, software based digital flight controls and avionics systems in flight essential and flight critical applications.

Agency Outputs: The FAA establishes rules for aircraft operation in icing conditions and the electromagnetic environment, software, digital flight controls, avionics systems, and electromagnetic hazards. It also publishes advisory circulars (AC) to outline acceptable means for meeting the rules and disseminates various forms of technical information to agency certification and airworthiness specialists, agency inspectors, and to the aircraft and avionics industry. The program fosters development of promising technologies such as sensors, to detect frozen contamination, and anti-icing fluid failure. The aircraft icing project joins with the Society of Automotive Engineers (SAE) in annual updates to aircraft holdover time guidelines. These provide time estimates of the effectiveness of de/anti-icing fluids.

Customer/Stakeholder Involvement: The program directly supports the FAA Strategic Plan Mission Goal for Safety: By 2007, reduce U.S. aviation fatal accident rates by 80 percent from 1996 levels. The program directly supports the Safety Strategic Focus Area of Accident Prevention. It does this through enhancements to aircraft certification, inspection, and maintenance relative to atmospheric hazards and advanced software and digital systems. It also directly supports Challenge 2000 through research and increased awareness in the area of software and standardization efforts among the certification directorates. In addition, it supports the free flight initiative, addressing highly integrated avionics and ground based systems safety and certification issues, using very complex software. A key supporter is the Aviation Rulemaking Advisory Committee (ARAC) Electromagnetic Effects Harmonization Working Group (EEHWG).

The ARAC Flight Test Harmonization Working Group (FTHWG) addresses performance and handling requirements standardization, and guidance material for operation in icing conditions. The ARAC Ice Protection Harmonization Working Group (IPHWG) addresses definition of an icing environment that includes Supercooled Large Droplets (SLD) and means, such as ice detectors, to discriminate between conditions within and outside the certification envelope and to warn flightcrews of ice accumulation on critical surfaces. An SAE committee also address aircraft lightning protection (AE-2). This committee develops ACs, test standards, and related users manuals to improve flight safety. The FAA provides leadership to the SAE G-12 Aircraft Ground Deicing Committee. This committee addresses holdover time guideline updates, standards establishment for de/anti-icing

methodologies and fluids, and sensor criteria to determine the existence of frozen contamination. It also addresses the failure of anti-icing fluids on critical aircraft surfaces.

Accomplishments: The program provided aircraft icing regulatory guidance and operating procedures to aircraft manufacturers and operators. This consisted of technical reports, handbooks, information bulletins, ACs and rules. Since 1992, the program has updated or issued two ACs, five technical bulletins, and the Aircraft Icing Handbook (twice), and it has published more than 35 technical reports or papers, including reports on ice phobic technologies. It has held international conferences on aircraft ground deicing (more than 600 participants from more than 10 countries), on aircraft in-flight icing (more than 400 participants from 20 countries), and on mixed-phase and glaciated icing conditions (more than 50 participants from five countries). It has also issued holdover time guidelines for deicing and anti-icing fluids.

In the area of software and digital systems safety, the program completed a software mutation study to assess the structural coverage testing requirements for avionics software. The program completed the third Streamlining Software Aspects of Certification (SSAC) Workshop in which numerous avionics software development and approval processes were identified for improvement. A feasibility study for an In-flight Advisor for civil aircraft was also published.

In the electromagnetic hazards area, the program published two reports measuring the closest approach distance between aircraft and emitters. The program also published a HIRF Risk Analysis Report used in support of a notice of proposed rulemaking. An update to the FAA Research and Development Electromagnetic Database (FRED 2.0) containing lightning strike data and waveforms was published and distributed. The update included C-160 Aircraft lightning strike data.

R&D Partnerships: The program has established many cooperative relationships, including the following:

- ARAC, EEHWG international certification authority/industry forum – HIRF environment, User's Guide for AC 20-1317.
- SAE–AE-2 Lightning Protection of Aircraft, Lightning Environment, Waveforms and Testing Standard, Aircraft Zoning Standard, and User's Manual for AC 20-136.
- RTCA Special Committee-135, "Environmental Conditions and Test Procedures for Airborne Equipment."
- RTCA Special Committee-180, "Design Assurance Guidance for Airborne Electronic Hardware."
- RTCA Special Committee-182, "A Minimum Operational Performance Standard (MOPS) for an Avionics Computer Resource (ACR)."
- RTCA Special Committee-190, "Software Considerations in Airborne Systems and Equipment Certification."
- Multiyear FAA/NASA interagency agreement with Langley Research Center to cooperate in the assessment of software based digital flight controls and avionics systems and electromagnetic hazards research.
- Multiyear interagency agreement with Naval Air Warfare Center Aircraft Division to assess the HIRF environment for aircraft.
- Letter of agreement to leverage HIRF certification research with Sandia Corporation, Army Directorate for Applied Technology, Test and Simulation, and ORION International Technologies, Incorporated.
- Certification Authorities Software Team (CAST) consisting of avionics software systems certification authorities from U.S., Europe and Canada.
- Cooperative efforts on aircraft icing activities with the NASA Lewis Research Center.
- Aircraft icing has more than six grants and agreements in place with academia and other government agencies to "leverage" interests and capabilities.
- An international agreement exists with Transport Canada on research on aircraft ground deicing issues.

- An international memorandum of cooperation exists with the Atmospheric Environment Service of Canada for research on in-flight icing conditions.

  An Interagency agreement with the Air Force for development of a new icing tanker for military and commercial use.

  ARAC IPHWG directly supported with data on and analysis of SLD conditions in the atmosphere.

MAJOR ACTIVITIES AND ANTICIPATED FY 2000 ACCOMPLISHMENTS:

Aircraft Icing

- Evaluated time effectiveness of recently developed new and environmentally friendly deicing/anti-icing fluids, including assessment of effect of removal of trialazols.
- Completed report on glycol temperature buffer reduction investigation.
- Completed report on fabrication of active aircraft mounted wide area ice detector prototype system.
- Published report on consolidation of SLD data at flight altitudes.
- Published report on artificial ice shapes used in certification.

Software and Digital Systems Safety

- Published Report on Avionics Software Mutation approach to structural coverage requirements in RTCA DO-178B.
- Published report on COTS software and hardware alternative certification methods.
- Published plan for Complex Hardware Case Study based on RTCA SC-180, DO-TBD document.

Electromagnetic Hazards to Aircraft Systems

- Published HIRF User's Guide for AC 20-1317.
- Published Lightning User's Manual for AC 20-136.
- Initiated a lightning strike characterization study for definition of aircraft lightning environment.
- Published In-service lightning strike data and analysis report.

KEY FY 2001 PRODUCTS AND MILESTONES:

Aircraft Icing

- Evaluate time effectiveness and aerodynamic performance of environmentally friendly and other modern fluids.
- Complete investigation of procedures and methods for laboratory determination of fluid holdover times.
- Publish report on improvement of icing simulation methods.
- Publish report on documentation and quantitative characterization of ice shape and roughness.
- Publish report on aerodynamic effects of residual and intercycle ice.

Software and Digital Systems Safety

- Publish report on certification considerations for COTS hardware and software.

Electromagnetic Hazards to Aircraft Systems

- Publish report on single event effects and upset.
- Publish update report on analysis of commercial in-service lightning data.
- Publish report on characterization of aircraft lightning environment.

FY 2001 PROGRAM REQUEST:

Aircraft Icing

- Continue to collect and assess the global atmospheric icing environment data, including steps to acquire data from operational aircraft.
- Determine acceptance criteria for icing tankers, tunnels, and analytical icing computer codes.

Software and Digital Systems Safety

- Continue research relative to emerging flight safety and certification issues identified by CAST and RTCA SC-190 efforts.

Electromagnetic Hazards to Aircraft Systems

Continue research relative to lightning protection, HIRF protection, electromagnetic compatibility, in-service lightning data, single event effects/upset and continued integrity research.

A06d - Flight Safety/Atmospheric Hazards Research Product and Activities	FY 2001 Request ($000)	Program Schedule					
		FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY2005
064-110 Flight Safety							
Software and Digital Systems Safety	$168						
Published Report on Software Structural Coverage Using Mutation Testing		◆					
Publish Report on Certification Considerations for COTS Software & Hardware			◇				
Publish Report on Certification Acceptance Criteria for Software Service History				◇			
Publish Case Study Concerning Certification Techniques for Complex Electronic Hardware				◇			
Publish Report on Acceptance Criteria for Software Reuse					◇		
Publish Report on Certification Considerations for Object Oriented Technology						◇	
064-111 Atmospheric Hazards							
Aircraft Icing	$1,691						
Continue Collecting Atmospheric Icing Data Aloft		◆	◇	◇	◇		
Evaluate Time of Effectiveness and Aerodynamic Performance of Environmentally Friendly Modern Fluids		◆	◇	◇	◇		
Reported on Fabrication of Active Aircraft Mounted Wide Area Ice Detector Prototype System		◆					
Reported on Consolidation of Supercooled Large Droplet (SLD) Data at Flight Altitudes		◆					
Repored on Glycol Temperature Buffer Reduction Investigation		◆					
Publish Report on Documentation & Quantitative Characterization			◇				
Report on Acquisition of Atmospheric Icing Data from Operational Aircraft			◇				
Report on Global Atmospheric Icing Environment						◇	
Publish Fluid Failure and Holdover Times Procedures for Manufacturers						◇	
Report on New Ice Phobic Technologies							◇
Electromagnetic Test and Analysis	$807						
Published High Intensity Radiated Fields (HIRF) User's Guide		◆					
Published Lightning User's Manual for Advisory Circular (AC) 20-136		◆					
Publish Report on Single Event Effects and Upset			◇				
Publish Update Report on Analysis of Commercial In-Service Lightning Database			◇				
Publish Report on Characterization of Aircraft Lightning Environment			◇				
Publish Analytical Zoning Technique Report					◇		
Publish HIRF Protection Analysis Techniques Report							◇
Personnel and Other Costs	$1,443						
Total Budget Authority	**$4,109**	**$3,844**	**$4,109**	**$4,208**	**$4,329**	**$4,474**	**$4,642**

Note: Out year numbers are for planning purposes only. Actual funding needs will be determined through the annual budget process.

Budget Authority ($ in Thousands)	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Enacted	FY 2001 Request
Contracts	1,368	705	1,494	1,943	2,666
Personnel Costs	577	1,127	973	1,744	1,349
Other Costs	118	231	152	157	94
Total	2,063	2,063	2,619	3,844	4,109

A06e Aging Aircraft

GOALS:

Intended Outcomes: The FAA intends to improve aviation safety by developing technologies, technical information, procedures, and practices that ensure the continued airworthiness of aircraft structures and components in the civil transport fleet. The aging aircraft research program focuses principally on:

- Analytical methodologies development and validation to predict the onset of widespread fatigue damage (WFD) and residual strength of aircraft structures.
- Nondestructive inspection (NDI) techniques development and validation to detect and quantify damage in the forms of corrosion, cracking, disbonding, and material processing defects.
- Flight and landing loads airworthiness standards updates and validation by acquiring/analyzing actual usage data for civil transport aircraft.
- Maintenance and repair requirements and procedures establishment for airframes.
- Crack growth based predictive methodology development to derive inspection and maintenance programs for non-rotating, safety critical components of aircraft engines.
- Damage tolerance methodology, health/usage monitoring methodology, and updated design load spectrums (based on actual usage) for the rotorcraft fleet.
- Aging nonstructural systems research. The development of information, technology and techniques to ensure the continued safe operation of aircraft electrical and mechanical systems.

Agency Outputs: The FAA establishes rules for aircraft certification, inspection, maintenance, and repair and publishes Advisory Circulars (AC) to outline acceptable means for compliance. Additionally, the agency disseminates technical information in various forms to its airworthiness inspectors and to industry. These outputs improve aircraft construction and maintenance practices. The objective of all of these products is to improve flight safety by increasing the continued airworthiness of aircraft. The aging aircraft research program provides the technical information necessary to support these agency outputs.

Customer/Stakeholder Involvement: The FAA has established an extensive network for collaboration in aging aircraft, including:

- The Aviation Rulemaking Advisory Committee (ARAC) is a FAA/industry forum established to ensure that industry's resources are used to their fullest extent and that the agency's rulemaking achieves intended results. ARAC also identifies requirements and priorities for supporting R&D activities.
- The FAA-sponsored Technical Oversight Group on Aging Aircraft (TOGAA) ensures effective coordination of aging aircraft program activities with related activities in Department of Defense (DOD) and industry. TOGAA meets several times a year to assess program progress and review research priorities in light of technical progress and the needs of aircraft manufacturers, operators, and maintainers.
- The Subcommittee on Aircraft Safety of the FAA Research, Engineering and Development Advisory Committee completed a review of the aging aircraft program. The program described here is fully responsive to the advice of the subcommittee.
- The aging aircraft program directly supports the Aviation Safety Research Act of 1988 (Public Law 100-591). This Act increased the scope of the FAA's mission to include research on methods for improving maintenance technology and detecting the onset of cracking, delamination, and corrosion of aircraft structures. In particular, this legislation directed the FAA to focus attention on maintaining the airworthiness of the aging commercial fleet.
- The aging nonstructural systems research program is the primary vehicle for supporting the recommendations of the White House Commission on Safety and Security, which states that "in cooperation with airlines and manufacturers, the FAA's Aging Aircraft Program

should be expanded to cover non-structural systems."

Accomplishments: Completed in 1998, the Full-Scale Aircraft Structural Test Evaluation and Research (FASTER) facility, located in the Safety Research and Development area at the FAA William J. Hughes Technical Center, is capable of testing full-scale curved panel specimens under conditions representative of those seen by an aircraft in actual operation. The data obtained from the tests will be used to validate analytical models being developed by the FAA. All testing is monitored using state-of-the-art video equipment for continuous observation. The test system, developed under contract with the Boeing Company, Long Beach, CA, features a unique adaptation of mechanical, fluid, and electronic components. It will be capable of applying pressurization, longitudinal, hoop, and shear loads to a curved panel test specimen.

The FAA's Airworthiness Assurance Nondestructive Inspection Validation Center (AANC), located in Albuquerque, NM, continues to expand. The Center has specialized in the performance of comprehensive, independent, quantitative evaluations of new and enhanced NDI, maintenance, and repair techniques. The hangar facility contains several aging aircraft, large fuselage sections, and a sample structural defect library. Aircraft test articles include a B-747, B-737, DC-9, HU-25A, Fairchild Metro II, UH-1H, and TH-57 aircraft.

Civil transport flight and ground loads data collection programs for large as well as small transport aircraft have been reestablished. To collect flight loads data, optical quick access recorders have been installed on several B-737, B-757, B-767, MD-82, and A-320 aircraft, and usage data is being analyzed. Similar recording technology is being employed to collect data on BE-1900D and CRJ commuter aircraft.

The FAA is conducting a series of video landing parameter surveys at high capacity commercial airports to better understand typical contact conditions for a wide variety of aircraft and airports and how they relate to current aircraft design criteria and practices. Airplane landing contact parameters have been obtained from the analysis of video images recorded during surveys conducted at representative high activity commercial large transport and commuter airports. To date, five such surveys have been completed at John F. Kennedy International Airport, Washington National Airport, Honolulu International Airport, London City Airport in the United Kingdom, and Philadelphia International Airport. Recently, a four camera video landing survey facility was established at the Atlantic City International Airport to collect landing usage data to characterize both fair and poor weather operations.

R&D Partnerships: Program activities are closely coordinated with related initiatives underway in industry and at NASA and DOD. The FAA, DOD, and NASA have cosponsored several conferences in the area of aging aircraft and airworthiness assurance. Interagency agreements are in place between the FAA and NASA, U.S. Navy, U.S. Air Force, and Department of Energy (DOE). International agreements are in place between the FAA and the regulatory authorities in the United Kingdom, the Netherlands, Australia, and Canada. A Memorandum of Cooperation is in place between the FAA and Russia.

The FAA Center of Excellence for Airworthiness Assurance (AACE), established in FY 1997, was formed with a broad mission in aircraft and aircraft systems safety research. AACE is a consortium consisting of eight core universities, Sandia National Laboratories, and more than 100 affiliates from government, industry, and academia.

The Center for Aviation Systems Reliability (CASR) is a consortium of four universities, Iowa State University, Northwestern University, Wayne State, and Ohio State University, formed to develop NDI techniques.

The Airworthiness Assurance Nondestructive Inspection Validation Center (AANC) is a partnership with Sandia National Laboratory to test and evaluate inspection techniques in a realistic hangar environment and enhance technology transfer.

The Engine Titanium Consortium (ETC), is comprised of Iowa State University, Pratt & Whitney, General Electric, and Allied-Signal; it was formed to develop methods for the inspection of engine components.

Numerous research grants have been awarded and are in place with universities and not-for-profit

laboratories to leverage their interests and capabilities. Cooperative research and development agreements (CRDAs) are in place with several airline operators as part of the flight loads data collection program.

MAJOR ACTIVITIES AND ANTICIPATED FY 2000 ACCOMPLISHMENTS:

- Completed development of an engineering manual with guidelines to predict the onset of widespread fatigue damage (WFD) and residual strength and structures.
- Initiated an FAA-industry jointly funded study to conduct a destructive investigation of an aging aircraft to evaluate its susceptibility to WFD.
- Developed user friendly software tool for damage tolerance analysis and design of aircraft repairs for commuter aircraft.
- Enhanced a general purpose damage tolerance computer program, NASA Growth (NASGRO), to assess the structural integrity of commercial aircraft.
- Conducted research on new Digital Flight Data Recorder (DFDR) criteria to accurately characterize control surface movement.
- Published flight loads data reports for various transport and commuter aircraft models.
- Published landing load data reports from video landing parameter surveys.
- Together with industry, performed supplemental nondestructive and destructive testing on wiring system components.
- Concluded testing of aged circuit breakers to determine if the performance of these circuit breakers has degraded below the original manufacturer's specification.
- Develop a prototype testing or inspection device to identify hazardous conditions involving aircraft wire.
- Develop first generation, prototype arc fault circuit interrupter for aircraft applications.

KEY FY 2001 PRODUCTS AND MILESTONES:

- Continue enhancement to user-friendly software tool for damage tolerance analysis and design of aircraft repairs for commuter aircraft.
- Continue the FAA-industry jointly funded investigation of the susceptibility of an aging airframe to WFD.
- Continue development and validation of enhanced inspection systems for engine components.
- Continue development and validation of inspection techniques to detect damage in airframe structures typical of widespread fatigue damage.
- Continue flight and landing loads data collection, analysis, and reduction for large transport and commuter aircraft.
- Complete a report on the destructive testing of flight control linkages.

FY 2001 PROGRAM REQUEST:

In FY 2001, the program continues to focus on the areas listed at the beginning of the GOALS section above. The near-term emphasis is on a better understanding of the effects of widespread fatigue damage, developing supplemental inspection requirements to better account for airframe and component damage, developing and validating enhanced inspection techniques, and understanding the effects of aging on nonstructural systems.

A06e - Aging Aircraft Product and Activities	FY 2001 Request ($000)	Program Schedule					
		FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY2005
065-110 Aging Aircraft							
WFD and Residual Strength Analysis	$7,349						
Completed Development of an Engineering Manual with Guidelines for Onset of Widespread Fatigue Damage (WFD)		◆					
Initiated Destructive Examination of Aging Airframe		◆					
Complete Destructive Examination of Aging Airframe and Publish Results					◇		
Continue Development & Validation of Inspections Techniques		◆	◇	◇	◇		
Develop Prototype for Detection of WFD-Size Cracks						◇	
Commuter Aircraft Requirements	$1,012						
Develop and Continue Enhancement of User Friendly Software Tool for Damage Tolerance Analysis and Design of Aircraft Repairs for Commuter Aircraft		◆	◇	◇			
Enhanced General Purpose Damage Tolerance Computer Program to Assess the Structural Integrity of Commercial Aircraft		◆					
Airborne Data Monitoring Systems	$1,540						
Publish Technical Report and Continue Data Collection Analysis on Flight Loads		◆	◇	◇	◇	◇	◇
Conduct Video Landing Parameter and Loads Survey at Philadelphia, Denver and Other Airports		◆	◇	◇	◇	◇	◇
Published Flight Loads Data Reports for Various Transport and Commuter Aircraft Models		◆					
Inspection for Engines	$3,597						
Continue Development and Validation of Enhanced Inspection Systems for Engine Components			◇	◇	◇	◇	◇
Complete Development of Ultrasonic Inspection Tools for Engines						◇	
Rotorcraft Structural Integrity	$822						
Complete Final Health/Usage Monitoring System (HUMS) Advisory Circular (AC) and Compliance Guidance for Part 29 & 27 Rotorcraft							◇
Update AC 29-2A and 27-1 for Fatigue and Damage Tolerance							◇
Aging of Nonstructural Systems	$4,003						
Concluded Circuit Breaker Testing on Performance Degradation		◆					
Performed Testing on Wiring System Components		◆					
Develop First Generation, Prototype Arc-Fault Circuit Interrupter for Aircraft Applications		◆	◇	◇	◇		
Complete Assessment of Feasibility of Service Life for Aircraft Wire		◆	◇	◇	◇		
Develop a Prototype Testing or Inspection Device to Identify Hazardous Conditions Involving Aircraft Wire		◆	◇	◇	◇		
Complete a Report on the Destructive Testing of Flight Control Linkages			◇				
Personnel and Other Costs	$4,061						
Total Budget Authority	$22,384	$21,594	$22,384	$22,752	$23,251	$23,886	$24,671

Note: Out year numbers are for planning purposes only. Actual funding needs will be determined through the annual budget process.

Budget Authority ($ in Thousands)	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Enacted	FY 2001 Request
Contracts	10,585	18,466	11,945	17,714	18,323
Personnel Costs	2,742	2,551	2,381	3,547	3,451
Other Costs	562	532	368	333	610
Total	13,889	21,540	14,694	21,594	22,384

A06f Aircraft Catastrophic Failure Prevention Research

GOALS:

Intended Outcomes: The FAA intends to improve system safety by developing technologies and methods to assess risk and prevent potentially catastrophic defects, failures, and malfunctions in aircraft, aircraft components, and aircraft systems.

The aircraft catastrophic failure prevention program focuses principally on using historical accident data and National Transportation Safety Board (NTSB) recommendations to examine and investigate known problem areas, such as:

- Turbine engine uncontainment events, including mitigation and modeling of uncontainment and aircraft vulnerability to uncontainment (AC20-128, phase II).
- Propulsion malfunctions and potential solutions with the help of industry.
- Explosive fuel tank issues, where the current focus is on the Fuel Quantity Indication System wiring and the impact of sulfide deposits.
- The accurate modeling of turbine engine imbalance.

Agency Outputs: The FAA establishes certification criteria for aircraft and publishes Advisory Circulars (AC) to outline acceptable means for meeting these rules. The program's objective is to ensure safe aircraft operation in the public domain.

The aircraft catastrophic failure prevention program provides the technical information necessary to support these agency outputs.

Customer/Stakeholder Involvement: The FAA continues to establish collaborative efforts such as the following to ensure a balanced, responsive aircraft catastrophic failure prevention program:

- The Aviation Rulemaking Advisory Committee (ARAC) is a FAA/industry forum established to ensure that agency rulemaking achieves intended results, and that the resources of industry are fully utilized in accomplishing these results. ARAC also identifies requirements and priorities for supporting R&D activities. The ARAC Powerplant Installation and Harmonization Working Group (PPIHWG) provides guidance to this program for the update of AC20-128.
- The FAA sponsors a series of workshops on turbine engine uncontainment characterization, modeling, and mitigation. This forum brings together industry and government (civil and military) to review progress to date on this subject and to recommend future courses of action.
- The FAA has developed partnerships with industry through the ARAC Power Plant Installation Harmonization Working Group to collaborate in developing a modeling toolkit for the modeling of engine uncontainment events.
- The FAA supports the Aerospace Industries Association (AIA) - Transport Committee (TC) project examining propulsion system malfunctions and inappropriate crew response. This project brings industry and the FAA together to recommend courses of action to foster safety and to develop associated regulations and advisory materials.
- The ARAC Fuel Tank Harmonization Working Group provides guidance to this program on issues related to fuel tank explosions.
- The program also responds to Public Law 100-591 (the Aviation Safety Act) and Public Law 101-508 (the Omnibus Reconciliation Act), which together established the aircraft catastrophic failure prevention program.

Accomplishments: Results of the catastrophic failure prevention program research are provided to certification officials to form the technical basis for rule changes as well as new or modified ACs. Results are also provided to airframe and engine manufacturers and designers. Recent accomplishments include:

- Developed the uncontainment data base and experimental test data needed by ARAC to develop new guidance for uncontained turbine engine failure methodology.
- Developed improvements to an aircraft vulnerability model to predict aircraft vulnerability to engine uncontainment events.

- Completed development of advanced material DYNA-3D fabric tensile failure model.

R&D Partnerships: Through interagency agreements, grants, and contracts, program activities are closely coordinated with government, academia, and commercial experts to leverage the full advantage of existing knowledge and technologies. Significant program benefits are realized from the following agreements:

- Interagency agreement with Naval Air Warfare Center Weapons Division, China Lake, which partners with Boeing to modify military vulnerability analysis tools. These tools are used in examining the vulnerability of commercial transport aircraft to turbine engine uncontainment events.
- Interagency agreement with Lawrence Livermore National Laboratory, which partners with Boeing, Allied Signal Engines, and Pratt & Whitney, to develop a modeling toolkit to address turbine engine uncontainment events modeling.
- Center of Excellence contract with SRI, which partners with University of Dayton Research Labs and Arizona State University, and in-kind support provided by Boeing and B. F. Goodrich.
- Interagency Agreement with NASA Glenn for cooperation on turbine engine uncontainment.

MAJOR ACTIVITIES AND ANTICIPATED FY 2000 ACCOMPLISHMENTS:

Engine Uncontainment Research.

- Developed an aircraft vulnerability model improvement plan and continue to make model improvements in cooperation with ARAC.
- Initiate expansion of the advanced material DYNA-3D model to include failure modes and fabric interaction identified in system impact testing.

Explosive Fuel Tank Issues.

- Issued interim report on problem of copper-silver sulfide contamination on fuel quantity indicating systems.

KEY FY 2001 PRODUCTS AND MILESTONES

Engine Uncontainment Research.

- Continue modifications to vulnerability code based on airframe manufacturers' evaluations.
- Complete work on a calibrated design tool to model engine uncontainment debris impact with titanium and aluminum aircraft materials.

Propulsion Malfunction

- Develop a plan for producing engine malfunction materials in conjunction with Flight Standards.

Explosive Fuel Tank Issues.

- Continue research into explosive fuel tank issues, focusing on the formation of sulfidation products in fuel tanks.

FY 2001 PROGRAM REQUEST:

The program continues to modify aircraft vulnerability codes to incorporate suggestions obtained from airframe manufacturers' evaluations. It continues developing a calibrated design system, for certification purposes, to examine engine uncontainment by developing toolkit components that model mitigation effects of advanced materials and improve penetration equations for aluminum and titanium.

The program also develops engine malfunction materials to better define a variety of propulsion malfunctions, including turbine engine surge.

Lastly, the program will continue to be responsive to the ARAC Fuel Tank Harmonization Working Group in examining issues and potential solutions to the explosive fuel tank issue.

A06f - Aircraft Catastrophic Failure Prevention Research Product and Activities	FY 2001 Request ($000)	Program Schedule					
		FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY2005
066-110 Aircraft Catastrophic Failure Prevention Research							
Engine Uncontainment Research	$1,235						
Complete DYNA-3D Model for Titanium and Aluminum			◇				
Developed an Aircraft Vulnerability Model Improvement Plan and Continued to Make Model Improvements		◆					
Complete Development of a DYNA-3D Model of Advanced Containment and Mitigation Materials				◇			
Continue Modifications to Vulnerability Code Based on Airframe Manufacturers' Evaluations			◇				
Complete Vulnerability Model				◇			
Complete Work on the Calibrated Design System for Certification Purposes				◇			
Explosive Fuel Tank Issues	$427						
Issued Interim Report on Problem of Copper-Silver Sulfide Contamination on Fuel Quantity Indicating Systems		◆					
Continue Research into Sulfide Deposits			◇				
Continue Work on Sulfide Deposits					◇		
Continue Support of Aviation Regulatory Advisory Committee (ARAC) for Fuel Tanks							◇
Propulsion Malfunction	$475						
Develop a Plan for Producing Crew Training Materials for Propulsion Related Malfunctions in Conjunction with Flight Standards			◇				
Produce Crew Training Materials in Conjunction with Flight Standards				◇			
Develop Recommendations for Engine Malfunction Monitor Systems						◇	
Personnel and Other Costs	$645						
Total Budget Authority	$2,782	$1,981	$2,782	$2,834	$2,902	$2,986	$3,089

Note: Out year numbers are for planning purposes only. Actual funding needs will be determined through the annual budget process.

Budget Authority ($ in Thousands)	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Enacted	FY 2001 Request
Contracts	2,650	3,289	1,329	1,308	2,137
Personnel Costs	369	590	397	607	610
Other Costs	75	121	61	66	35
Total	3,094	4,000	1,787	1,981	2,782

A06g Aviation Safety Risk Analysis

GOALS:

Intended Outcomes: The FAA will continue to increase its collaboration with industry in their mutual search for programs and systems with true potential for increasing aviation safety. Accordingly, the partners will build on their previous collaboration to improve risk assessment, safety performance measurement and the shared use of safety related data. The Aviation Safety Risk Analysis (ASRA) program focuses primarily on:

- Design/Development and/or enhancement of risk management/decision support tools embedded in FAA analytical systems, e.g., flight standards service Safety Performance Analysis System (SPAS), and the aircraft certification service safety management program products. These tools encompass particulars about air carriers, aircraft design, aircraft maintenance, discrepancy reports, repair stations (both domestic and foreign) aviation training schools, and air personnel.
- Development of advanced risk assessment indicators/safety performance measures and graphical techniques. These allow the FAA to more effectively and efficiently use information contained in various FAA and industry databases.
- Establishment of a forum with industry to exchange aviation risk assessment/risk management and safety performance measures models and methodologies.
- Establishment of a systems engineering and system safety risk assessment effort in support of certification, surveillance, investigation, and certificate management.
- Development of a safety analysis methodology that will be used first to certify new products in light of continued airworthiness issues and then to deploy those products under test conditions to increase the operational safety of the fleet.
- Development of a risk based tool to manage aircraft certification workload and prioritize oversight activities related to manufacturers.
- Development and/or enhancement of the Maintenance Malfunction Information Reporting (MMIR) System with capabilities to track critical helicopter parts, to capture part utilization/performance data, and to perform trend analysis on the captured data.
- Development of guidelines for evaluating U.S. military surplus flight safety critical aircraft parts for installation on FAA U.S. type certified products.
- Development of a methodology for performing large scale software system reliability prediction and testing cost measures.

Agency Outputs: The Federal Aviation Act of 1958 and the Federal Aviation Regulation (FAR) provide the FAA the statutory authority and responsibility to conduct surveillance of air operators, air agencies, aircraft, and airmen to ensure conformance with the FAR and aviation safety standards. The outputs from the Aviation Safety Risk Analysis research program improve the data, data gathering techniques, analysis, and risk management/decision support tools needed for FAA certification, surveillance, investigation, and certificate management processes. These outputs enable systematic risk assessment and safety performance measurement to take proactive steps to reduce the rate of aviation-related accidents and incidents. Based on insights from risk analysis, the FAA targets and increases its leverage of aviation safety inspector and certification engineering resources.

Customer/Stakeholder Involvement: The Federal Aviation Authorization Act of 1996 requires that the Administrator give "high priority to developing SPAS." The legislation calls for deployment of SPAS II, initiated in FY 1997, to be completed by December 1999. ASRA enhances SPAS decision support capabilities through additional risk analysis/predictive models, expert system capabilities, and critical safety performance indicators.

In 1997, the Flight Standards Service introduced their new business process, the Air Transportation Oversight System (ATOS); a system based approach to FAA certification, surveillance, and certificate management oversight. ATOS is designed to provide the FAA with the people, procedures, equipment, facilities, software, tools, and materials necessary to make surveillance

more systematic and better targeted to deal with identified risks. The ASRA program will provide systems engineering; analyses in the form of design of safety performance measures, data sources, analysis methodologies, information presentation; and system safety risk assessment research (such as hazard analysis, design of risk indicators, Markovian Models, and Aviation System Risk Models) in support of this effort.

The ASRA Program responds directly to the Safer Skies Agenda, recommendations in the Challenge 2000 Report and the FAA 90-day Safety Review. Maximum information sharing alerts both the FAA and industry to pending aviation safety related problems. Developing a certification and surveillance program built on targeting resources to address safety risks ensures that corrective action is taken much sooner. Thus, the primary beneficiaries of this effort are the general flying public.

Several analytical tools, such as SPAS, will be used by the Department of Defense in their oversight of defense contract carriers and charters.

The FAA worked with Helicopter Association International to develop and release the maintenance malfunction information reporting system. This software tool has improved the collection, storage, and transfer of service difficulty reports and part warranty information.

Data improvement and standardization efforts respond to recent Congressional hearings and the General Accounting Office (GAO) report recommendations that the FAA increase the quality and timeliness of their aviation safety data. More importantly, analytical and decision support tools rely on high quality data to identify potential safety risk areas.

Accomplishments: Full deployment of SPAS II was initiated in FY 1997 and was completed by December 1999. This is a computer based analytical tool used by FAA aviation safety inspectors and certification engineers, as well as DOD aviation analysts, to support the oversight activities of FAA certificate holders (i.e., air operators, air agencies, aircraft, and air personnel). A study was initiated to establish baseline risk parameters related to continued airworthiness of aircraft and to analyze the factors which generally precede aircraft accidents.

R&D Partnerships: The U.S. Air Force Air Mobility Command provides technical support and assistance in developing safety critical performance measures. Discussions have been initiated with the Department of the Interior (DOI) regarding a partnership with DOI for sharing aviation safety data. An interagency agreement was established with the Department of Energy (DOE), enabling Sandia National Laboratories to contribute their technical expertise in developing system design, development, and safety, as well as safety performance measures, risk indicators, and the implementation of a data quality improvement strategy. The Air Carrier Operations System Model (FAR Part 121) will be developed with several major air carriers. The Helicopter Association International (HAI) continues to work with the FAA to develop and enhance the Web based Maintenance Malfunction Information Reporting (MMIR) system that now accepts data from helicopter on-board Health, Usage and Monitoring systems (HUMS) for safety analysis and condition based maintenance monitoring. Several university grants have been awarded to support the development and testing of aviation safety risk models. For example, Rutgers University is contributing to the development of the Intelligent Decision Support Tool and the Aviation System Risk Model.

MAJOR ACTIVITIES AND ANTICIPATED FY 2000 ACCOMPLISHMENTS:

Risk Management Decision Support

- Initiated the design of flight standards next generation safety critical performance measures and risk indicators based on system engineering and system safety models of FAR Part 121. These tasks were accomplished in conjunction with industry.
- Implemented new and enhanced risk analysis models and capabilities.
- Developed and incorporated safety critical performance measures into flight standards (SPAS II).
- Initiated a decision support system requirements study.

- Continued workshops with industry to discuss aviation risk analysis and safety performance measurement methodologies and tools.
- Continued to develop risk/hazard/accident models and tools based on FAR Part 121.
- Completed the development of a prototype Intelligent Safety Performance and Evaluation System.
- Initiated the development of the Aviation Safety Risk Management System.
- Released the Air Personnel Module.
- Conduct a repair station information requirements study and analysis.

Aircraft Maintenance: Maintainability and Reliability.

- Completed FAA order on Eligibility and Evaluation of U.S. Military Surplus Flight Safety Critical Aircraft Parts, Engines and Propellers.
- Completed a handbook on Eligibility and Evaluation of U.S. Military Surplus Flight Safety Critical Aircraft Parts, Engines and Propellers.

Safety Analysis Methodology

- Initiate development of a methodology that will enable the Aircraft Certification Systems Evaluation Program (ACSEP) to focus on those areas statistically found to have the greatest impact on aviation safety.
- Initiate the development of probabilistic safety assessment efforts that address aircraft systems safety.

KEY FY 2001 PRODUCTS AND MILESTONES:

Risk Management Decision Support

- Continue to develop, test, and validate new and enhanced risk analysis models and capabilities.
- Continue to develop risk assessment indicators and safety critical performance measures using enhancements to the system engineering and system safety models based on FAR Part 121 in conjunction with industry.
- Release the Repair Station Component Prototype.
- Initiate the development of a system engineering model based on FAR Part 135 operations.
- Continue workshops with industry to discuss aviation risk analysis and safety performance measurement models and methods.
- Continue the development of the Aviation Safety Risk Management System.
- Initiate the design of decision support system options analysis.
- Continue the development of Risk/Hazard/Accident models and tools.

Aircraft Maintenance - Maintainability and Reliability

- Initiate analysis in support of an Advisory Circular (AC) entitled, Eligibility and Evaluation of U.S. Military Surplus Flight Safety Critical Aircraft Parts, Engines, and Propellers.
- Enhance the Maintenance Malfunction Information Reporting (MMIR) System with capability to integrate with other aircraft safety monitoring system such as HUMS.
- Establish criteria for utilizing Built-in Test Equipment (BITE) as an approval for return aircraft to service.
- Complete an AC on inspection procedures regarding Flight Safety Critical Aircraft parts, engines and propellers.

Safety Analysis Methodology

- Continue the development of probabilistic safety assessment efforts that address aircraft systems safety.
- Integrate ACSEP improvement methodology into current system and develop software tools to deploy improvements to field.

FY 2001 PROGRAM REQUEST:

In FY 2001, research continues to focus on the areas listed at the beginning of the GOALS section above. Data assimilation, analysis, and tool development continue in support of ASRA initiatives. The analysts work with government, industry, and academia aviation safety subject matter experts to ensure that risk management/

decision support tools, including safety critical performance measures and risk indicators are properly defined, developed, tested, and evaluated prior to implementation. The program investigates, tests, and recommends improvements, including standardization, to the quality (and quantity) of data used in the performance measures. It also completes studies to identify and verify flight standards and aircraft certification safety information requirements.

A06g - Aviation Safety Risk Analysis Product and Activities	FY 2001 Request ($000)	Program Schedule					
		FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY2005
060-110 Aviation Safety Risk Analysis							
Risk Management Decision Support	$3,370						
Design Flight Standards Next Generation Safety Critical Performance Measures and Indicators Based on System Engineering and System Safety Models based on FAR Parts 121/135		◆	◇	◇	◇	◇	◇
Develop, Test, Validate and Enhance Risk Analysis Models and Capabilities		◆	◇	◇	◇	◇	◇
Develop and Implement Safety Critical Performance Measures into Flight Standards SPAS II		◆	◇	◇	◇	◇	◇
Conduct a Decision Support System Requirements Study		◆					
Conduct Workshops with Industry to Discuss Aviation Risk Analysis and Safety Performance Measurement Methodologies and Tools		◆	◇	◇	◇	◇	◇
Develop Risk/Hazard/Accident Models and Tools based on FAR Parts 121/135		◆	◇	◇	◇	◇	◇
Develop the Aviation Safety Risk Management System		◆	◇	◇			
Develop System Engineering Models Based on FAR Parts 121/135		◆	◇				
Design the Decision Support System Options Analysis Model			◇	◇	◇	◇	◇
Release the Air Personnel Module			◇				
Develop Repair Station Prototype		◆	◇	◇			
Aircraft Maintenance: Maintainability & Reliability	$600						
Completed Handbook on Eligibility and Evaluation of US Military Surplus Flight Safety Critical Aviation Parts, Engines, and Propellers		◆					
Establish Criteria for Utilizing Built-In Test Equipment (BITE)			◇				
Enhance the Maintenance Malfunction Information Reporting (MMIR) System			◇	◇	◇		
Initiate Analysis in Support of Advisory Circular: Eligibility & Evaluation of US Military Surplus Flight Safety Critical Aircraft Parts, Engines and Propellers		◆	◇	◇			
Develop MIS Data Base			◇				
Safety Analysis Methodology	$480						
Develop and Integrate an Aircraft Certification Systems Evaluation Program (ACSEP) Improvement Methodology			◇	◇			
Develop Methodology for Comprehensive Safety Analysis of Aircraft Systems			◇	◇	◇		
Personnel and Other Costs	$2,207						
Total Budget Authority	$6,657	$6,824	$6,657	$6,780	$6,939	$7,140	$7,383

Note: Out year numbers are for planning purposes only. Actual funding needs will be determined through the annual budget process.

Budget Authority ($ in Thousands)	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Enacted	FY 2001 Request
Contracts	3,619	5,289	5,555	5,286	5,165
Personnel Costs	316	1,039	794	1,393	1,414
Other Costs	65	213	122	145	78
Total	4,000	6,541	6,471	6,824	6,657

2.4 Aviation Security Program Area Description

Mission

The FAA Aviation Security Research and Development (R&D) Division is the lead establishment within the FAA responsible for R&D programs related to civil aviation security. The division's mission is to perform research and development to help prevent civil aviation security incidents through programs that accelerate and expand R&D and support the deployment of advanced technologies. Products of the division lead to equipment and methods designed to counteract criminal and terrorist attacks against civil aviation. This mission provides assistance in anticipating future threats to civil aviation and emphasizes the need to rely less on human intervention for detection and deterrence. Well integrated, automated aviation security systems that leverage benefits from a variety of technologies will produce better operational performance.

Intended Outcomes

The main goal for the Aviation Security R&D Program is to deter or detect criminal and terrorist threats to civil aviation and mitigate the effects of incidents that occur. This promotes public confidence and has direct economic benefit to the aviation industry. The increasing extent and sophistication of terrorism make it necessary for the FAA to identify and develop practical, effective technologies applicable to aviation security systems. These systems must be comprehensive and extensive enough to address all potential aviation security vulnerabilities at the airport, in loading and servicing the aircraft itself, and at air traffic control facilities.

The Aviation Security Program is conducting extensive R&D on the detection of explosives, weapons, and other more sophisticated threats to prevent their placement on board aircraft. The Aviation Security R&D Program focuses on automated aviation security systems and screening protocols that enable the highest throughput and at both the least intrusive and most effective, thus minimizing passenger delays and inconvenience. Aviation Security also conducts R&D to identify methods to harden the aircraft to mitigate the damaging effects of explosives, weapons, surface to air missiles, and electromagnetic interference.

Program Area Outputs

The FAA, through the Aviation Security R&D Program, promotes the development of technologically improved products and procedures in explosives detection, aircraft hardening, airport security, and human factors. Program outputs include:

- Developing a structured, total airport security system definition and concept of operations for distribution to FAA R&D security planners.
- Developing R&D test protocols and performance criteria to aid in the operational deployment of improved aviation security systems.
- Providing information and data defining standardized methods of security screener selection, training and performance evaluation.
- Testing explosives resistant baggage containers.
- Exploring other blast mitigation techniques to ensure that potentially catastrophic criminal and terrorist acts do not result in the loss of lives and aircraft.

Aviation Security R&D products are systems, devices, technologies, specifications, analysis tools, technology integration plans and procedures. These products are for use by airports, air carriers, airframe manufacturers, and screening companies to improve civil aviation security.

Program Area Structure

The Aviation Security R&D Program accomplishes its mission by dividing the program into four interrelated areas: Explosives and Weapons Detection, Aircraft Hardening, Human Factors, and Airport Security Technology Integration. Each program area makes a different but significant contribution toward achieving the goal of a safe and secure air transportation system.

The focus of the *Explosives and Weapons Detection* program area is to develop new, or to improve existing methods and technologies to detect explosives and weapons in checked and carry-on baggage, on passengers, or in air cargo. The weapons detection program promotes pre-board screening to prevent the armed takeover of air-

craft. This program area assists with development of standards and specifications for test and certification or approval of detection equipment.

The major purpose of the *Aircraft Hardening* program area is to conduct research to increase civil aircraft survivability in the event of an in-flight explosion. Additionally, this program seeks to identify the type and minimum weight of an explosive that could cause catastrophic damage or aircraft loss. The program also develops methods to protect aircraft avionics and systems from the damaging effects of false electromagnetic or high-energy signal interference.

The objective of the *Aviation Security Human Factors* program area is to improve the human element of the aviation security system. The program develops methods to select the screener as well as measure and improve screener performance levels, especially important as aviation security components merge into future integrated systems. Emphasis is placed on the capabilities and constraints of manpower: training, human factors engineering, and the health and safety aspects of human performance.

The *Airport Security Technology Integration* program area focuses on technologies that prevent unauthorized access to aircraft and airport facilities. Major emphasis is on recommending future system designs and concepts of operation while evaluating and promoting operational readiness and suitability. Technology products include analytical models, state-of-the-art perimeter control, and passenger/baggage matching technologies that prevent unaccompanied baggage from being loaded on board aircraft. This program develops simulation and modeling tools. One set of tools performs airport security (vulnerability, risk and blast effects) analysis while the other set is used to seamlessly integrate, improve, and reduce operating costs for technologies developed by other programs in the Aviation Security R&D Program area.

The FAA Aviation Security R&D Program conducts six R&D projects to achieve the goals of the four Aviation Security R&D budget line items. The three R&D projects, titled Checked Baggage, Cargo/Mail, and Checkpoint support the Explosives and Weapons Detection budget line item. The other three areas, Aircraft Hardening, Human Factors, and Airport Security Technology Integration, each have a dedicated budget line. Any one program will not solve all the issues. Technology development has not reached a point where it can operate autonomously. The Aviation Security R&D Program embraces a systems-oriented approach that balances the application of people, procedures, and technology to each threat and vulnerability.

Customer/Stakeholder Involvement

- The Aviation Security Improvement Act of 1990 (Public Law 101-604, codified as 49 U.S.C. 44912) provides direction for the FAA's System Security Technology Program. The FAA's Office of Civil Aviation Security Policy and Planning imposes research requirements in the following areas:
- Checkpoint
- Checked Baggage
- Mail and Cargo
- Chemical and Biological Agents
- Explosives Detection Canines
- Human Factors
- Airport Security Technology Integration
- Aircraft Hardening
- Independent Test and Evaluation

In 1996, the White House Commission on Aviation Safety and Security strongly emphasized continued R&D in all program areas, and recommended the deployment of existing explosives detection technology. Congress funded further R&D and the FAA's purchase and installation of explosives detection systems (EDS) and explosives detection devices (EDD). The FAA Security Equipment Integrated Product Team (SEIPT) is purchasing and deploying advanced security equipment at various airports throughout the United States.

Other stakeholders include the National Academy of Sciences, the Aviation Security R&D Scientific Advisory Panel, the R&D Advisory Council, and the Aviation Security Advisory Committee, which hold frequent reviews of R&D plans and results. Efforts also include interagency work with the Technical Support Working Group. Their recommendations include changes in the direction or emphasis of research plans.

Accomplishments

The FAA Aviation Security R&D Program has been in effect since 1974. Note the following significant accomplishments:

- In November 1994, certified the InVision CTX 5000 and established a demonstration effort that delivered four certified CTX 5000 EDS to air carriers for operational testing. FAA certification criteria examines three performance areas including detection, false alarms and throughput requirements. The CTX 5000 conducts a pre-scan and produces cross sectional slices in the areas of interest. Data collection and analysis have taken place at airports in San Francisco, Atlanta, and Manila.
- In October 1998, certified the L-3 Communications eXaminer 3DX6000 EDS. The eXaminer 3DX6000 scans and analyzes the entire bag using a cone beam at a rate of about five seconds per bag and renders a full 3D image. This is the second company to meet the FAA certification criteria for explosives detection.
- In April 1999, certified the InVision CTX 9000 DSi Galileo.
- The Aviation Security R&D Program is developing a low cost Explosive Detection System (ARGUS system consisting of multiple units) for use at smaller airports. Competitive grant solicitations are scheduled for late FY 99.
- The Aviation Security R&D Program staff provided critical input for the SEIPT's effective deployment, which began in January 1997. To date 79 CTX 5500 EDS have been installed in airports.
- The Aviation Security R&D Program staff provided support for the deployment of over 470 explosives trace detection devices to U.S. airports with more scheduled in FY 2000.
- Trace detection prototypes for screening personnel using devices such as portals and document scanners are being developed and evaluated both in the laboratory and in airport environments.
- The Aviation Security R&D Program conducted explosives testing on various aircraft to provide data to validate and refine explosives detection criteria. These tests included a Boeing 747 test performed jointly with the United Kingdom, a Lockheed L1011 test performed with the manufacturing community, and vulnerability testing on DC-9 and 727 aircraft.
- The Aviation Security R&D Program supported the 1996 Olympics in Atlanta by deploying explosives trace detection devices and the CTX 5000 system. Aviation Security is also supporting the 2000 Olympics in Australia.
- The Aviation Security R&D Program is conducting a demonstration effort on hardened LD-3 baggage containers with three commercial air carriers.
- In August 1999, Aviation Security R&D Program completed a MANPAD study on the effectiveness of Infrared systems against external aircraft lighting.
- The Aviation Security R&D Program, in cooperation with U.S. Air Force Phillips Laboratory, will complete in FY99 a study on the vulnerability of commercial aircraft to High Powered Microwave and other directed energy weapons.
- The Aviation Security R&D Program established criteria to limit cross-contamination of explosives used to train and certify explosives detection canine teams.
- As part of the goal to improve screener selection and performance, Aviation Security R&D Program is developing a Screener Readiness Test. This test, owned by the government, will determine when the screener has received sufficient initial training. Data to determine the baseline for this study is being collected by Delta in Atlanta, Northwest in Detroit, and Alaska Airlines in Seattle.
- The Aviation Security R&D Program performed an international study of radio frequency identification tags. This technology will make positive passenger baggage matching (PPBM) cost effective and operationally feasible when deployed in the field.
- The Aviation Security R&D Program completed an industry-wide, economic analysis

on the costs of PPBM, and provided the results to both industry and FAA rule making teams.

- The Aviation Security R&D Program completed the Blast/FX model, which has been distributed to over 250 Federal users in many government agencies. The Blast/FX effects model shows the structural effect of explosives on airport facilities and projects casualties based on explosive weight and airport configuration scenarios.
- The Aviation Security R&D Program evaluated many approaches to assessing airport vulnerability and risk, and adopted one approach for use by FAA agents at airports. Development of the tool and associated training will be completed in FY99, with nationwide implementation scheduled for FY00.
- The Aviation Security R&D Program's developmental efforts resulted in a signed agreement between Sandia National Laboratories and Barringer Inc. for the production of personnel portals that detect a wide range of explosives. Sandia developed the portal under an FAA contract supported by the Aviation Security R&D Systems Development Branch. FAA anticipates the delivery of limited production models from Barringer in mid FY 2000.
- The Aviation Security R&D Program developed Threat Image Projection (TIP) systems to measure screeners' on-the-job performance.
- The Aviation Security R&D Program also developed the Computer-Assisted Passenger Pre-screening System (CAPPS) to reduce the number of passengers needing special security screening.
- The Aviation Security R&D Program developed a long-range cargo plan to evaluate new procedures and promising technologies.

R&D Partnerships

Since its inception, the Aviation Security R&D Program has fostered the establishment of productive relationships with many organizations. These organizations include U.S. government agencies, industry, academia, and foreign countries that promote technology development for improved aviation security. Each of the FAA's cooperating organizations contributes to the Aviation Security R&D mission by providing information, R&D, equipment, and/or facilities. The FAA uses these partnership agreements to leverage its Aviation Security R&D project investments. Recent projects in partnership include:

- Bilateral agreements with the United Kingdom, France, Canada and Israel for exchange of information, development of new explosives detection technologies, and cooperation on joint ventures as well as test and evaluation.
- Cost sharing agreements with manufacturers continue to develop additional sources for certified EDS. Systems, expected to come to market in FY 99, will increase the efficiency and effectiveness of available detection options while reducing cost through competition.
- A cost sharing agreement with Alaska Airlines and with Northwest Airlines to identify and develop methods utilizing advanced technologies to improve screener performance. A third cost sharing agreement with Delta Airlines is pending.
- In support of the aircraft hardening program, expertise from the U.S. Air Force, Army and Navy, as well as NASA and Department of Energy, to develop and test hardened LD-3 containers for wide body aircraft as well as cooperation with several airlines for the operational evaluation of prototypes.
- A partnership, through another government organization and a foreign government, to investigate the practicality of developing hardened containers for use on narrow body aircraft.
- A cooperative agreement with the State of Illinois on the Security of Cargo Shipments.

Long-Range View

The FAA envisions an integrated aviation security system for the 21st century that incorporates the strengths of a variety of technologies that are continuously monitored and upgraded to respond to changes in the threat environment. This integrated system will enable aviation security professionals to perform at maximum levels of effectiveness. The application of automated detection

technologies will enhance screener performance by providing detection that is constantly vigilant and impervious to distraction or fatigue as in the case of human or canine screeners. This understanding of the aviation security system of the future provides guidance and direction for future Aviation Security R&D Program efforts and supports decisions affecting FAA investments.

Terrorist capabilities and techniques will continue to increase and evolve. This ever-changing threat necessitates continued security R&D funding for the foreseeable future. Aviation Security R&D Program efforts will continue to focus on modifications and other technical improvements to deployed explosives detection equipment. Identification and evaluation of explosives mitigation techniques will also continue. The focus of effort will continue to expand to include the entire aviation spectrum, including airports, airplanes, and other areas of the National Airspace System.

A07a Explosives and Weapons Detection

GOALS:

Intended Outcomes: The Explosives and Weapons Detection program strives to accelerate development and application of advanced technology to eliminate the ability of terrorists to conceal improvised explosives devices, weapons, and flammable gas or liquid explosives on aircraft. Its efforts directly support the security mission in the FAA Strategic Plan.

The program fosters the developments of improved Explosives Detection Systems (EDS) and Devices (EDD) and makes them available to the airlines and groups responsible for domestic and international airline security. Specifically this program:

- Provides automated security systems capable of processing today's increasing air travel demands at minimal cost to participating facilities.
- Enhances the security of the worldwide flying public.
- Promotes adaptation of the best existing and emerging U.S. technologies in response to continually evolving threat possibilities.

Agency Outputs: The FAA publishes directives and rules detailing how the airlines must comply with national security policies. This rulemaking process depends upon research and development, testing and evaluation, and the creation of data packages in support of equipment mandates. The program's continuous involvement in present and future threat detection, and its resulting outputs, effectively enhance the security of the flying public.

The FAA has deployed both Bulk and Trace explosives detection systems through the Security Equipment Integrated Product Team (SEIPT).

Customer/Stakeholder Involvement: The FAA is the world leader in developing explosive detection research, and in testing and evaluating related equipment. Through this program, the FAA:

- Interacts with industry, academia, other government agencies, oversight groups, special interest groups, Congress, foreign governments, national laboratories, individual researchers and the general public to solve their common problems.
- Sponsors respected special interest groups, including the National Academy of Science and the Committee on Civil Aviation Security of the National Research Council (NRC), to assess security research initiatives and to review explosives detection research priorities. [The NRC committee meets several times a year for its panels to address specific crucial topics such as personnel screening and the configuration management of explosives detection hardware and software. Their findings and recommendations directly affect the program's strategy and concepts.]
- Responds to congressional mandates such as P.L. 101-604, the Aviation Improvement Act of 1990, the White House Commission on Aviation Safety and Security, the Aviation Security Advisory Committee Baseline Working Group, the General Accounting Office (GAO), and section 303 of the Federal Aviation Administration Reauthorization Act of 1997.

Accomplishments: Explosives detection research results are provided to the Office of Civil Aviation Security to aid in the rulemaking process. Since 1991, the program has:

- Identified new potential threats of mass destruction and characterized them as to detectability.
- Identified contamination levels on/in luggage and on people associated with certain explosives.
- Evaluated multiple explosives trace detection systems for deployment.
- Developed and certified the world's first competitive EDS: Invision CTX.
- Certified a moderate throughput EDS with advanced user interface: Invision CTX 5500.
- Developed and certified two high throughput EDSs: Invision CTX 9000 and L-3 Examiner.
- Developed prototype Nuclear Quadrupole Resonance (NQR) simulants.

- Developed a complete suite of inert, non-toxic x-ray of simulant explosives (secondaries) for various agencies.
- Established test and evaluation criteria and protocols for checked baggage, checkpoint and cargo.
- Developed a worldwide accepted trace detection standard for electronic items.
- Held two international symposia on explosives detection.
- Sponsored three International Society for Optical Engineering (SPIE) conferences on domestic and international explosives detection.
- Conducted an International Civil Aviation Organization (ICAO) workshop on trace detection standards for electronics explosives detection.
- Completed an airport demonstration of certified explosives detection equipment at San Francisco and Atlanta international airports.
- Supported the 1996 Olympic games with explosives detection equipment installations at five airports.
- Developed competing technologies to the certified EDS.
- Developed and tested personnel portal scanning prototypes.
- Provided support to the SEIPT for airport deployment of bulk and trace detection equipment.
- Tested carry-on baggage screening with the operator assist function.

R&D Partnerships: The explosives detection program works closely with academia, industry, and other national laboratories. Partnerships with organizations reduce costs, where possible, by combining research initiatives that use the same technologies for slightly different purposes. More than ninety contracts, grants, CRDAs, and interagency agreements are in place with industry, academia and other government agencies. R&D partnership activities include:

- Joint funding agreements, cooperative research and development agreements, and consultation agreements through which Industry and the FAA collaborate to improve existing and develop new carry-on, checked, and cargo scanning systems.
- Over a dozen projects supported through interagency working relationships, such as with DOE laboratories, DOD facilities, U.S. Department of Agriculture (USDA), Office of the Secretary of the Treasury (OST), U.S. Customs, and Volpe Transportation Systems Center.
- Bilateral agreements between the FAA and several international counterparts.
- Work with the Interagency Technical Support Working Group—a body that supports explosive detection projects that can be applied to other agencies; these include document scanners, cargo screening systems, miniaturization, and performance improvement of trace detection technologies and industry collaboration with foreign governments' technology development.
- Work with the NRC Committee on Commercial Aviation Security—a body that regularly reviews the explosives/weapons detection program and makes recommendations supporting further developments.

MAJOR ACTIVITIES AND ANTICIPATED FY 2000 ACCOMPLISHMENTS:

Checked Baggage Screening Technology.

- Reduced false alarm rate in fielded EDS systems.
- Performed R&D to enhance performance of explosives detection canines.
- Developed requirements and explored low cost EDS for small airports.
- Certified a lower cost, lower throughput EDS.
- Developed directed trace screening protocol.

Checkpoint Technology.

- Developed explosive standards for luggage and personnel.
- T&E of trace personnel devices to augment checkpoint security.
- Developed at least three checkpoint research centers/test beds.
- Developed an automated carry-on prototype.

- Developed trace detection standards for personnel screening.
- Designed and tested at least two advanced, integrated checkpoint system designs.
- Developed a fast holographic passenger screening prototype.
- Tested at least one ticket and/or token trace scanner.
- Developed NQR wand prototype.

Cargo Security Technology.

- Completed evaluation of commercially available screening systems for containerized/palletized cargo.
- Determined feasibility of using trace for cargo screening.
- Developed automated cargo profiling system.
- Developed training protocols for manual search of cargo.

KEY FY 2001 PRODUCTS AND MILESTONES:

Checked Baggage Screening Technology.

- Evaluate coherent scattering system.
- Develop and certify low cost throughput EDS.
- Develop prototype trace based automated EDS.

Checkpoint Technology.

- Optimize performance of NQR for luggage.
- Explore advanced bottle scanners.
- Enhance/develop systems to handle emerging threats.
- Enhance/develop and test combined technology personnel inspection system utilizing bulk and trace technologies.
- Develop and test NQR wand system for passengers and bags.

Cargo Security Technology.

- Complete evaluation of EDS technology for screening break bulk cargo.
- Complete guidelines for matching EDS technologies to cargo types.
- Complete training protocols for manual search of cargo.
- Complete threat assessment between cargo and other vectors.
- Develop guidelines for matching EDS technologies to cargo types.
- Complete training protocols for non-intrusive screening of cargo.

FY 2001 PROGRAM REQUEST:

The program develops or enhances technologies that detect or discover emerging threats in both the trace and bulk detection areas. Capabilities are added to existing or new systems to handle threats not addressed by current technologies. In each case, standards are developed to characterize the performance of the newly developed system capabilities.

Combined technologies are used that merge a system's ability to analyze and integrate data from multiple sensors, thus providing an improved detection over single system capability. This applies to baggage, cargo, and personnel scanning devices. The results of this research should increase the probability of detection and decrease the false alarm rates over existing technologies performing similar individual functions. New combinations of devices are being considered for use in environments inaccessible to public view.

Research continues into the development of faster, more automated, and cheaper systems, which could more easily be integrated into an airport environment. The program makes maximum use of data and experience gained from deploying existing equipment.

A07a - Explosives and Weapons Detection Product and Activities	FY 2001 Request ($000)	Program Schedule					
		FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY2005
071-110 Explosives/Weapons Detection							
Checked Baggage Screening Technology	$15,290						
Developed Detonator Detection Technology		◆					
Develop Low-Cost Explosives Detection System (EDS) for Low Throughput Stations		◆	◇	◇			
Develop High Throughput EDS for 100% Screening		◆	◇	◇	◇	◇	◇
Performance Improvement of Deployed Systems	$2,000						
Reduce False Alarms		◆	◇				
Integrate Alternative Technologies		◆	◇	◇	◇		
Develop Trace-Based EDS		◆	◇	◇	◇		
Develop Integrated Multi-Technology EDS	$2,500						
Certify EDS Upgrades		◆	◇	◇	◇	◇	◇
Test and Evaluation		◆	◇	◇	◇	◇	◇
Develop Fast, Non-Invasive Passenger Screening Systems:	$6,250						
Develop and Test Trace Portals		◆	◇	◇	◇	◇	
Develop and Test Low-Cost Passenger Portals				◇	◇	◇	◇
Develop and Test Fast, Hand-Held Explosive Detection Wands				◇	◇	◇	◇
Develop and Test Ticket Trace Scanners		◆	◇	◇	◇	◇	
Develop Automated Carry-On Baggage Inspection Systems:	$500						
Develop and Test Fast, Integrated Bottle Contents Scanners		◆	◇	◇			
Design and Test Optimized, Integrated Checkpoint Systems					◇	◇	◇
Develop Checkpoint Research Centers and Testbeds		◆	◇	◇	◇	◇	◇
Cargo Security Technology	$5,400						
Develop Automated Cargo-Profiling System		◆	◇				
Operational Evaluation of Automated Cargo Profiling System			◇	◇			
Develop Guidelines for Matching EDS Technologies to Cargo Types			◇				
Complete Threat Assessment between Cargo and Other Vectors		◆	◇				
Develop Contingency Plans for Enhanced Cargo Threat			◇		◇		
Complete Ground Transit Security Study		◆	◇				
Develop Training Protocols for Manual Search of Cargo		◆					
Develop Training Protocols for Screening of Cargo		◆	◇				
Evaluate Containerized/Palletized Inspection Systems		◆					
Develop Advanced Screening Technologies for Cargo		◆	◇	◇			
Evaluate Trace and Bulk Explosives Detection Technology		◆	◇				
Enhance Cargo Security Demonstration Project				◇	◇	◇	◇
Personnel and Other Costs	$5,520						
Total Budget Authority	**$37,460**	**$37,605**	**$37,460**	**$38,019**	**$38,798**	**$39,812**	**$41,081**

Note: Out year numbers are for planning purposes only. Actual funding needs will be determined through the annual budget process.

Budget Authority ($ in Thousands)	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Enacted	FY 2001 Request
Contracts	38,629	30,832	37,696	32,299	31,940
Personnel Costs	2,297	2,796	3,462	4,827	4,682
Other Costs	471	572	542	479	838
Total	41,397	34,200	41,700	37,605	37,460

A07b Airport Security Technology Integration

GOALS:

Intended Outcomes: This program supports the security mission in the FAA Strategic Plan and it addresses specific aviation security vulnerabilities and reduction of international security incidents through cooperation with foreign governments. The program strives to block terrorist access to the aircraft through analysis of airport vulnerabilities, investigation of advanced perimeter control surveillance systems, and development of systems that provide for strict accountability for luggage loaded onto an aircraft.

Additionally, the program supports other aviation security programs by:

- Identifying advanced threats that the aviation community may face in the near future.
- Developing sophisticated models to predict the operational effects of inserting security measures into the existing aviation system.
- Evaluating security devices in terms of operational suitability and supplementing the development of reliable equipment.

Overall progress on meeting these goals results from: (1) providing methods to objectively analyze impacts on passenger flow and costs associated with security risk mitigation; (2) identifying and developing new technologies, methodologies, and procedures to enhance the performance of security professionals in the performance of their aviation security mission; and (3) developing and maintaining an integrated security system approach for countermeasures to the identified threats of the civil aviation system.

Agency Outputs: The FAA establishes the regulations governing airport and airline security and the rules for security inspections. The FAA publishes these rules and regulations, with guidance for their implementation, in the form of advisory circulars (AC). The airport security technology integration program also provides reports and analyses of technical information (such as airport vulnerability assessments) to aid the civil aviation security community in improving security methods.

Customer/Stakeholder Involvement: The FAA develops an extensive collaboration within the domestic and international aviation security communities. The R,E&D efforts include industry participation with the Air Transport Association (ATA) to study the operational costs and effects of positive passenger baggage matching (PPBM). This effort is designed to prevent the loading of unaccompanied baggage on aircraft. The FAA collaborates with the Societe Internationale De Telecommunications Aeronautiques (SITA) and the International Air Transport Association (IATA) in the development of standards for baggage tracking and reconciliation systems and tagging technologies. Collaboration with the Airport Consultants Council and most other major airport organizations is needed for development and revision of the Security Considerations for Airport Construction Guidelines.

The program responds to Public Law 101-604, the Aviation Security Act of 1990, the Aviation Security Advisory Committee (ASAC) recommendations, and the recommendations of the White House Commission on Aviation Safety and Security. These pieces of legislation provide impetus for security research requirements and dissemination of the research results to industry.

Accomplishments: Results of the airport security technology integration program are provided to the aviation community for their use, and to the Office of Civil Aviation Security, as follows, to assist them in the rulemaking process:

- Completed assessments of radio frequency (RF) technology for PPBM.
- Completed evaluations of commercial off-the-shelf (COTS) airport vulnerability assessment tools against developed functional requirements.
- Identified and refined a vulnerability/risk assessment method for use by FAA agents nationwide.
- Provided statistical analysis of findings to industry.
- Integrated security vulnerability countermeasures into operational test beds to validate security benefits and operational suitability.
- Completed bi-annual technical reports, which identify and prioritize advanced technical

threats against civil aviation. These reports drive research requirements and guide current and future research trends.

- Completed an airport explosives security survey analysis and correlated information to identify vulnerabilities across 76 domestic airports. Information was provided back to airports on areas of concern and corrective action.
- Published guidelines for industry on security revolving doors for use at concourse screening points.
- Published functional guidelines for a PPBM system.
- Developed an automated tool to assess facility and personnel damage from blast effects, and to estimate and evaluate the effectiveness of blast mitigation measures.
- Performed study on feasibility of detecting unauthorized personnel access based on existing ground surveillance radar.
- Investigated advanced airport security command and control methods.
- Identified opportunities for airport security and operations improvements using information integration.

R&D Partnerships: Through partnership with the RTCA Subcommittee (SC) 183 and participation of industry, developed a standard for airport security access control systems. Relationships with ATA and the Regional Aircarrier Association (RAA) focus on the study of economic effects of PPBM on the industry. A year long cooperative study culminated with the publication of a project report that analyzes the economic effects of PPBM on the aviation industry. The FAA continues this relationship to fulfill the requirements of the White House Commission on Aviation Safety and Security recommendations for PPBM. The Airport Security Technology Integration (ASTI) program determines the operational effects of alternative approaches to, and research of, technologies to increase the efficiency and security of reconciling baggage with passengers.

The program works with Airports Council International-North America (ACI-NA) to integrate operational airport design needs into a passenger baggage flow model (PBFM) tool. Upon completion, this software package will be transferred to industry for use as a tool in configuring security systems and technologies into the airport environment.

The program and the State of Illinois have cosponsored research on the security of cargo shipments in transit from the remote cargo facilities to the airlines' receiving points. Testing has determined the feasibility of a positive driver identification and cargo seal system. This project received national recognition as the leading innovative usage of technology.

The program has completed interagency agreements with the Department of Defense Office of Special Technology to coordinate technology assessments. Also, the agency coordinates efforts with the U.S. Air Force and the DOD Defense Special Weapons Agency on the simulation and modeling of blast effects and biological and chemical effects on aviation facilities. With the Technical Support Working Group, the program is represented on the Executive Oversight Committee for development of Automated Tools for Vulnerability Assessment.

The ASTI program has lead the FAA's Airport Vulnerability Assessment effort. The resulting process has been accepted by the airport community as a result of the continuous involvement of the American Association of Airport Executives (AAAE), ACI-NA and the Airport Law Enforcement Agency Network (ALEAN).

Relationship with the National Center for Biometrics Testing at San Jose State University has brought valuable expertise to security projects involving positive human identity verification through the use of biometric devices (such as fingerprint, hand geometry, etc.).

Additionally, grants, cooperative research and development agreements (CRDA), and memorandums of understanding/agreement with industry, academia, and other government agencies provide leverage to the program in areas of mutual interest.

MAJOR ACTIVITIES AND ANTICIPATED FY 2000 ACCOMPLISHMENTS:

Domestic Air Travel

- Transferred assessments of RF technology for baggage tracking or PPBM to industry.
- Developed a protocol standard for explosives detection systems to communicate with baggage handling systems to ensure accurate tracking of alarmed bags.
- Completed a PBFM.
- Incorporated enhancements to blast effects model.
- Developed toxic effects model.

Airport Security

- Selected airport vulnerability assessment tools and methods, and developed an internal FAA capability for airport assessment.
- Revised and updated Airport Security Construction Guidelines.
- Established a reliability engineering program to influence and supplement security sensor development.
- Planned and conducted airport operational suitability tests on development-proven equipment.
- Refined the threat/countermeasures database.
- Developed an architecture for security monitoring equipment information integration.
- Researched advanced countermeasures.
- Developed operational test bed infrastructure at selected airports and the Technical Center's security operations center.

KEY FY 2001 PRODUCTS AND MILESTONES:

Domestic Air Travel

- Publish a threat analysis report for advanced threats to civil aviation security.
- Publish results of applications of the PBFM and the explosive blast model.

Airport Security

- Continuously evaluate EDS and other security vulnerability countermeasures in operational test beds.
- Refine airport vulnerability assessment methods used by field personnel.
- Maintain an evaluation scorecard for all security sensor development projects focused on assessing the operational suitability of these devices.
- Develop reliability and maintainability programs to supplement the performance oriented sensor development projects.
- Test emerging sensors and systems for low-cost performance intrusion detection.

FY 2001 PROGRAM REQUEST:

In FY 2000, the program is evolving toward a focus on operational suitability and systems engineering. The FY 2001 period will carry forward the operational emphasis with selected equipment operational evaluations in test-bed airports. This activity specifically supports the equipment transition activities of the Security Equipment Integrated Product Team (SEIPT), and will benefit from the lessons learned by field experience gained on SEIPT installed security equipment. The emphasis on systems engineering results in supplemental analyses and field evaluations of operational issues, equipment availability, reliability and maintainability. The end result is that equipment that completes the development cycle will not only achieve the required performance levels but will also be fully operationally suitable.

A07b - Airport Security Technology Integration Product and Activities	FY 2001 Request ($000)	Program Schedule					
		FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY2005
073-110 Airport Security Technology Integration							
Domestic Air Travel	$20						
Transferred Assessments of Radio Frequency (RF) Technology for Baggage Tracking or Positive Passenger Bag Match (PPBM) to Industry		◆					
Publish Threat Analysis Report for Advanced Threats to Civil Aviation Security			◇				
Developed a Protocol Standard for Explosives Detection Systems (EDS) to Communicate with Baggage Handling Systems to Ensure Accurate Tracking of Alarmed Bags		◆					
Completed Passenger and Baggage Flow Model		◆					
Incorporated Enhancements to Blast Effects Model		◆					
Publish Results of Applications of the Passenger Baggage Flow Model and the Explosive Blast Model			◇				
Developed Toxic Effects Model		◆					
Airport Security	$855						
Continuously Evaluate EDS & Other Security Vulnerability Countermeasures in Operational Testbeds			◇	◇	◇	◇	◇
Selected Airport Vulnerability Assessment Tools and Methods		◆					
Developed Internal FAA Capability for Airport Assessment		◆					
Revised and Updated Airport Security Construction Guidelines		◆					
Established a Reliability-Engineering Program to Influence and Supplement Security Sensor Development		◆					
Develop Reliability and Maintainability Programs to Supplement the Performance Oriented Sensor Development Projects			◇	◇	◇		
Plan and Conduct Airport Operational Suitability Tests on Development-Proven Equipment		◆	◇	◇	◇	◇	◇
Refine Threat/Countermeasures Data Base		◆	◇	◇			
Developed an Architecture for Security Monitoring Equipment Information Integration		◆					
Refine Airport Vulnerability Assessment Methods to Be Used by Field Personnel			◇		◇		◇
Maintain an Evaluation Scorecard for all Security Sensor Development Projects Focused on Assessing the Operational Suitability of these Devices			◇	◇	◇	◇	
Researched Advanced Countermeasures		◆					
Test Emerging Sensors and Systems for Low-Cost Performance Intrusion Detection			◇	◇	◇	◇	◇
Developed/Refined Operational Testbed Infrastructure at Selected Airports and Technical Center's Security Operations Center		◆					
Personnel and Other Costs	$1,587						
Total Budget Authority	$2,462	$2,285	$2,462	$2,555	$2,568	$2,772	$2,898

Note: Out year numbers are for planning purposes only. Actual funding needs will be determined through the annual budget process.

Budget Authority ($ in Thousands)	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Enacted	FY 2001 Request
Contracts	3,165	1,127	1,832	909	875
Personnel Costs	492	1,127	754	1,258	1,435
Other Costs	101	231	122	118	152
Total	3,758	2,485	2,708	2,285	2,462

A07c Aviation Security Human Factors

GOALS:

Intended Outcomes: The Aviation Security Human Factors program supports the FAA's Strategic Plan security goal to improve the detection of explosives and weapons within the NAS. Specifically, the program focuses its efforts upon establishing the baseline level of security and addressing related vulnerabilities.

This program leverages funding for equipment development to improve aviation security system performance through the following means:

- Optimize human performance contributions through better operator selection, training, and performance monitoring for the various detection technologies.
- Create better security machine interfaces and integration by merging individual detection systems into a combined technology system with optimized human performance contributions.

Agency Outputs: The FAA establishes standards for security activities and this program conducts R&D for technical input essential to:

- Reduce security costs as a result of automation.
- Reduce vulnerability to terrorist threats.
- Decrease risk of catastrophic financial loss resulting from sabotage of an airplane.
- Increase public confidence in the safety of air travel.
- Increase global U.S. industrial competitiveness.
- Improve security screener certification.

Customer/Stakeholder Involvement: The Aviation Security Human Factors program:

- Supports the Office of the Associate Administrator for Civil Aviation Security as mandated by the Aviation Security Improvement Act of 1990 (PL 101-604).
- Responds to requirements from the Aviation Improvement Act of 1990, the White House Commission on Aviation Safety and Security, Baseline Working Group on Aviation Security, and the General Accounting Office (GAO).
- Partners with multiple airlines to test and evaluate equipment, personnel and procedures.

Accomplishments: The following results of Aviation Security Human Factors research were provided to the Office of Civil Aviation Security to assist them in the rulemaking process:

- Refined the definition of knowledge, skills, and abilities needed for checkpoint screening.
- Developed functional requirements for the Screener Proficiency Evaluation and Reporting System (SPEARS) components of screener selection, training, and performance monitoring.
- Measured baseline checkpoint security performance.
- Developed screener selection tests for estimating future performance and interpreting both conventional X-ray and computed topography (CTX 5000) images.
- Developed computer based training (CBT) for both checkpoint operations and checked baggage evaluation with the CTX 5000.
- Developed threat image projection (TIP) for both conventional X-ray machines and the CTX 5000.
- Developed a duplicate checklist system.
- Developed a screener readiness test after initial training.
- Developed a computer-assisted passenger screening (CAPS) profiling system.
- Developed on-the-job completion tests.

R&D Partnerships: This program works closely with various agencies and groups, such as:

- Lawrence Livermore National Laboratory — inter-agency agreement.
- Domestic airlines and research organizations including:
  - Alaska Airlines
  - Delta Airlines
  - EG&G Astrophysics
  - Northwest Airlines
  - Public Computer Systems
  - Rapiscan Security Products

MAJOR ACTIVITIES AND ANTICIPATED FY 2000 ACCOMPLISHMENTS:

Screener selection/training/testing.

- Determined knowledge, skills, and abilities required for screeners to use emerging detection technologies.
- Improved screener selection, screener machine interfaces, CBT multimedia training, and performance monitoring systems for emerging detection technologies.
- Established criteria and data for rulemaking about screener selection, training, and proficiency assessment.
- Developed screener certification testing protocols.

Human Systems Integration (HSI).

- Completed evaluations of detection systems involving emerging technologies such as bottle screening and millimeter wave detection.
- Optimized combined detection technologies through component integration within futuristic screener stations.
- Integrated new and emerging detection technologies into the operational environment.
- Provided HSI evaluations on the manpower, personnel, training, human factors engineering, health, and safety aspects of security systems.

KEY FY 2001 PRODUCTS AND MILESTONES:

Screener selection/training/testing.

- Determine knowledge, skills, and abilities for using emerging detection technologies.
- Improve screener selection, screener machine interfaces, CBT multimedia training, and performance monitoring systems for emerging detection technologies.
- Establish criteria and data for rulemaking on screener selection, training, and proficiency assessment.
- Establish criteria and data to support rulemaking for screener certification.

Human Systems Integration (HSI).

- Continue to evaluate detection systems involving emerging technologies.
- Integrate new and emerging detection technologies into the operational environment.
- Provide HSI evaluations on the manpower, personnel, training, human factors engineering, health, and safety aspects of security systems, especially those involving EDS and weapons detection technologies.

FY 2001 PROGRAM REQUEST:

This program focuses on producing key FY 2001 products to accomplish stated goals. Results emphasize R&D within the areas of screener selection/training/testing, and human systems integration. The program improves screener selection, screener machine interfaces, CBT multimedia training, and performance monitoring systems for emerging detection technologies. This research provides the basis for establishing criteria and data for rulemaking. It evaluates detection systems involving emerging technologies such as bottle screening and millimeter wave detection. It also optimizes detection technologies through component integration within futuristic screener stations and integrates new and emerging detection technologies into the operational environment. Finally, it provides Human Systems Integration evaluations on the manpower, personnel, training, human factors engineering, health, and safety aspects of security systems, especially those involving EDS and weapons detection technologies.

A07c - Aviation Security Human Factors Product and Activities	FY 2001 Request ($000)	Program Schedule					
		FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY2005
076-110 Aviation Security Human Factors							
Screener Selection/Training/Testing	$1,955						
Determine Knowledge, Skills, and Abilities Required for Screeners to Use Emerging Technologies		◆	◇	◇	◇	◇	◇
Improve Screener Selection, Screener-Machine Interfaces, CBT Multimedia Training, and Performance Monitoring Systems for Emerging Detection Technologies		◆	◇	◇	◇	◇	◇
Establish Criteria and Data for Rulemaking about Screener Selection, Training and Proficiency Assessment		◆	◇	◇	◇	◇	◇
Developed Screener Certification Testing Protocols		◆					
Establish Criteria and Data to Support Rulemaking for Screener Certification			◇				
Human Systems Integration (HSI)	$2,162						
Provide HSI Evaluations on Manpower, Personnel, Training Human Factors Engineering, Health and Safety Aspects of Security Systems		◆	◇	◇	◇	◇	◇
Evaluate New Detection Systems (e.g. Bottle Screening, Millimeter Wave Detection)		◆	◇	◇	◇	◇	◇
Integrate New and Emerging Technologies into Operational Environment		◆	◇	◇	◇	◇	◇
Optimize Combined Detection Technologies through Component Integration within Futuristic Screener Stations		◆	◇	◇	◇	◇	◇
Personnel and Other Costs	$1,028						
Total Budget Authority	**$5,145**	**$5,256**	**$5,145**	**$5,234**	**$5,354**	**$5,502**	**$5,685**

Note: Out year numbers are for planning purposes only. Actual funding needs will be determined through the annual budget process.

Budget Authority ($ in Thousands)	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Enacted	FY 2001 Request
Contracts	4,446	4,723	4,078	4,114	4,117
Personnel Costs	492	679	1,064	1,032	921
Other Costs	101	138	140	110	107
Total	**5,039**	**5,540**	**5,282**	**5,256**	**5,145**

A07d Aircraft Hardening

GOALS:

Intended Outcomes: In accordance with the strategic goal of eliminating security incidents in the aviation system, the overriding goal of the program is to protect commercial aircraft from catastrophic structural or critical system failure due to an in-flight explosion. Secondary objectives are to investigate vulnerability from some spurious electromagnetic or high energy signal interfering with aircraft electronic systems and to assess the threat presented by manually operated, highly mobile, surface to air missiles.

The program is designed to determine and identify:

- Minimum size explosives that would result in aircraft loss.
- Methods and techniques that can be applied to the current and future fleet of commercial aircraft to decrease the level of vulnerability to explosive effects.
- Threats to aircraft from electromagnetic (EM), projected energy, and surface to air missiles and practical countermeasures.

Agency Outputs: The program is tasked with delivering documented explosive vulnerability data to the explosive detection community and, depending on research results, providing recommendations for rulemaking relative to mitigation techniques. In the area of other threats, the program provides reports to the staff of the Associate Administrator for Civil Aviation Security characterizing specific commercial aircraft vulnerability to threats as well as possible countermeasures. In order to meet these requirements, the program has been divided into the following separate projects: explosive vulnerability and aircraft design related mitigation techniques, container hardening, and protection against advanced terrorist threats.

Customer/Stakeholder Involvement: The aircraft hardening program was initiated in 1990 in response to the directives of the President's Commission on Aviation Safety and Security and the mandates set forth in the Aviation Security Improvement Act of 1990. The program is continually assessed by the Security Subcommittee of the FAA R,E&D Advisory Committee and has been subjected to scrutiny and endorsed by the General Accounting Office. The content of the program is in direct support of the customer, the Assistant Administrator for Civil Aviation Security, and complies with the aviation security requirements document of the Office of Civil Aviation Security. Additionally, the program is required to periodically report technical progress directly to Congress.

Accomplishments: The Aircraft Hardening program has:

- Validated current detection standards through analysis and explosive testing of the minimum size, type, and location of explosives, which could result in catastrophic aircraft failure.
- Proved the feasibility of and determined the standards for explosive resistant luggage containers used in wide body aircraft.

As a continuation to the container effort, which was suggested by various members of Congress:

- Provided prototype containers to the airlines to complete an operational assessment of the cost and improved security effectiveness of implementing hardened containers.
- While working with the Department of Defense and other government agencies:
- Developed a process to assess the vulnerability of commercial aircraft to terrorist induced electronic and mobile missile threats.

R&D Partnerships: From the onset, the program has used expertise from the U.S. Air Force, U.S. Army, and U.S. Navy as well as consulted with various Department of Energy laboratories and NASA. Relationships also have been established with the U.S. aircraft and container manufacturing industries and research efforts have been coordinated with the United Kingdom, Israel and France. The program uses the services of many defense and aircraft related industries. The prime program objective is the collection of data in support of rulemaking. As the program utilizes a wide spectrum of industry experts, all developed technologies have been or will be directly transferred to the appropriate private market.

MAJOR ACTIVITIES AND ANTICIPATED FY 2000 ACCOMPLISHMENTS:

Container hardening.

- Transitioned container technologies to private industry.
- Completed operational assessment of LD-3 hardened containers with airlines.
- Developed and tested protective luggage units for use on narrow body aircraft.

Aircraft vulnerability.

- Validated, through explosive testing, the blast effects of a variety of different explosives for the purpose of refining detection criteria.
- Assessed the practicality of protecting overhead compartments from explosive effects.

Projected energy, electromagnetic, and other terrorist threats.

- Identified possible mitigation techniques to counter projected energy and other threats.
- Developed procedures/rules for Man Portable Air Defense Systems (MANPADS).

KEY FY 2001 PRODUCTS AND MILESTONES:

Container hardening.

- Determine operational impacts of hardened baggage units on narrow body aircraft.
- Complete assessment of other than LD-3 size containers; make the decision on rulemaking.

Aircraft vulnerability.

- Assess security implications associated with the introduction of 800-1000 passenger jets.
- Validate appropriate new techniques including hardening of overhead compartments to mitigate explosive effects.
- Develop new aircraft certification criteria.

Projected energy, electromagnetic, and other terrorist threats.

- Develop procedures/rules for electromagnetic interface.
- Work with Department of Defense in assessing practicality of technical solutions to counter the man portable air defense systems.

FY 2001 PROGRAM REQUEST:

In FY 2001, the program continues to focus on the areas listed at the beginning of the GOALS section above. As the vulnerability assessments evolve, ideas to mitigate blast either through retrofitting the current fleet or instituting new design techniques and materials are being identified. These ideas and concepts are analyzed and tested and recommendations for new specifications are made as required. Special emphasis is placed on assessing and recommending hardening actions regarding the long-term implications of terrorism on new commercial aircraft concepts such as the 800 to 1000 passenger jumbo jets. In addition, analyses of the impact of EM, Projected Energy (PE), and MANPADS on commercial aircraft are underway and anticipated to be complete by the end of FY 2001. These research efforts are primarily investigative in nature and involve an assessment of the potential vulnerability of an aircraft to these threats.

A07d - Aircraft Hardening Product and Activities	FY 2001 Request ($000)	Program Schedule					
		FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY2005
075-110 Aircraft Hardening	$2,112						
Container Hardening							
Completed Operational Assessment of LD-3 Hardened Containers with Airlines		◆					
Complete Assessment of Other Than LD-3 Size Containers, Make Decision on Rulemaking			◇	◇			
Developed and Tested Protective Luggage Units for Use on Narrow Body Aircraft		◆					
Determine Operational Impacts of Hardened Baggage Units on Narrow Body Aircraft			◇	◇			
Develop rules for Narrow Body Protective Units			◇	◇	◇	◇	
Transition Container Technologies to Private Industry		◆	◇	◇	◇	◇	
Aircraft Vulnerability	$1,038						
Validated Through Explosive Testing, the Blast Effects of a Variety of Different Explosives for the Purpose of Refining Detection Criteria		◆					
Assessed the Practicality of Protecting Overhead Compartments from Explosive Effects		◆					
Assess Security Implications Associated with the Introduction of 800 - 1,000 Passenger Jets			◇				
Validate Appropriate New Techniques Including Hardening of Overhead Compartments to Mitigate Explosive Effects			◇	◇			
Develop New Aircraft Certification Criteria			◇	◇	◇	◇	◇
Projected Energy/Electromagnetics/Other Terrorists Threats	$275						
Identified Possible Mitigation Techniques to Counter Projected Energy and Other Threats		◆					
Developed Procedures/ Rules For Man Portable Air Defense Systems (MANPADS)		◆					
Develop Procedures/Rules for Electromagnetic Interface			◇				
Develop Procedures/Rules for Projected Energy			◇	◇			
Work with DoD in Assessing Practicality of Technical Solutions to Counter MANPADS			◇				
Publish Reports Identifying Cost-Effective Alternatives for Mitigating The Threat Of Electromagnetic, Projected-Energy Weapons and MANPADS			◇	◇	◇		
Assess Aircraft Design Implications Relative to Chemical/ Biological Threats			◇	◇	◇	◇	
Develop Procedures/Rules for Chemical/Biological Threat			◇	◇	◇	◇	◇
Personnel and Other Costs	$882						
Total Budget Authority	**$4,307**	**$5,001**	**$4,307**	**$4,383**	**$4,482**	**$4,609**	**$4,764**

Note: Out year numbers are for planning purposes only. Actual funding needs will be determined through the annual budget process.

Budget Authority ($ in Thousands)	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Enacted	FY 2001 Request
Contracts	6,268	1,393	1,139	3,371	3,425
Personnel Costs	492	504	754	1,497	801
Other Costs	101	103	107	133	81
Total	**6,861**	**2,000**	**2,000**	**5,001**	**4,307**

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2.5 Human Factors and Aviation Medicine Program Area Description

Mission

The Human Factors and Aviation Medicine Program will use:

- *Applied research*

  To identify methods that, when implemented, contribute to the goal of reducing the fatal accident rate by 80 percent, and

  To develop enhanced guidelines for protective equipment and procedures, and provide recommendations for FAA regulatory and medical certification personnel to enhance safety of aircraft crewmembers and aircraft cabin occupants.

- *Innovative research and management initiatives*

  To ensure that human factors policies, processes, and best practices are integrated in the research and acquisition of 100 percent of FAA aviation systems and applications.

The rapid evolution toward increased operational demand, diversity of aircraft and systems, changing technology, and globalization of the airline/aircraft industry challenges the Human Factors and Aviation Medicine Offices to meet these goals by:

- Ensuring that research is focused on those areas directly impacting aviation safety.
- Capitalizing on opportunities to leverage government and industry resources.
- Forming partnerships with research and university laboratories in order to rapidly transfer the results of research to the aviation community.
- Undertaking major efforts to ensure that human factors expertise is represented across functional disciplines and that human factors considerations are addressed throughout the FAA acquisition process.

Intended Outcomes

The Human Factors Research Program:

Human factors research is increasing the safety and efficiency of the NAS by developing scientifically validated information and guidance for improving the performance and productivity of air carrier crews, general aviation pilots, aviation maintenance and inspection personnel, air traffic controllers, and NAS system maintenance technicians. This program directly responds to FAA Strategic Plan goals to "eliminate accidents and incidents caused by human error" and to "implement new decision support systems and associated functional improvements that fully account for the proper role of people in the system." This research also provides human factors support that addresses the FAA goal to "reduce the costs of flying by making the air traffic management system more efficient to use."

Human factors research is developing human-centered flight controls and displays, and is increasing consideration of human factors in aircrew training. This research also explores prospects for safety enhancement through automated statistical analysis of flight-recorded data and through application of human factors in certification of new aircraft and equipment design and modification.

In aviation maintenance, human factors research develops more effective methods for maintenance technician and inspector training, and improves aviation maintenance technician and inspector task performance. Aviation maintenance human factors research efforts are exploring the application of human factors interventions to improve aviation inspection performance, evaluating the effects of Maintenance Resource Management, and examining human error risk analyses in aviation maintenance and flightline operations. Research is also producing programs used for improving aviation maintenance and inspector team communication to prevent shift change communication errors.

In general aviation, safety is enhanced through the application of human-centered principles to the development of advanced displays and controls and to procedures that improve pilot decision making and performance.

In air traffic control, human factors research will guide the development of human-centered automation and procedures to enhance controller decision making and to reduce error prone conditions. These efforts will also guide the development of tools and procedures to support the collaborative decision making required in the future NAS. An improved approach to classifying human factors associated with operational errors/incidents will result in recommendations for decreasing the frequency of those events.

Aviation Medicine research improves the health, safety, and survivability of aircraft passengers and aircrews through its identification of human failure modes and development of formal recommendations for counteracting human failure conditions. Through this research, the FAA develops bioaeronautical guidelines, standards, and models for aircraft cabin equipment, procedures, and environments as a basis for regulatory action to enhance appropriate human performance. New medical criteria, standards, and assessment/certification procedures are also developed to ensure full performance capability. By assessing flight attendant and passenger behavior and disease issues, guidelines will be proposed for actions to improve the health and safety of cabin occupants.

Program Area Outputs

The Human Factors Research Program:

- Identifies operational needs and problems involving human performance.
- Funds and guides research projects to address operational priorities.
- Forms partnerships with industry and academia.
- Elicits participation by the Nation's top scientists and professionals.
- Provides Human Factors guidance to the FAA for development and implementation of new technologies, training and procedures.
- Facilitates transfer of research products to the operational community.
- Produces data and other forms of information which support notices and regulations applicable to aircraft occupant health and safety.
- Develops output options to solve a public demand (e.g., better restraints for children in aircraft settings); and assesses disease transfer and other aircraft occupant health factors.

The FAA is concerned with ensuring the safety and efficiency of NAS operations, a critical element of which is operator performance. Through guidelines, handbooks, advisory circulars, rules, and regulations, the agency provides industry with human performance information and guidance critical to the design, operation, regulation, and certification of equipment, training, and procedures. The human factors program does the research which provides the technical information necessary to generate these products and services.

Automation has been cited as a contributing factor in aircraft accidents (e.g. Cali: AA965). Human factors research is examining flight deck automation design, operation, and use, and has developed a prioritized research agenda of issues to be addressed. Air carrier training initiatives such as the Model Advanced Qualification Program (air carrier pilot training program which integrates both technical and crew resource management performance requirements) will allow air carriers to develop and utilize proficiency-based training. The Automated Performance Measuring System will provide airlines the ability to analyze routine operations for dangerous trends and tendencies, and will provide insight into the details of daily carrier line operations.

Aviation maintenance research is developing and validating job aids for maintenance documentation. Validated pre-hire assessments for air traffic controllers, electronics technicians, and transportation system specialists will enable the FAA to select persons with appropriate knowledge, skills, and abilities for each occupation, thus reducing training required after employment as well as attrition due to poor person-job fit. Human factors assessments will be conducted to evaluate the performance and safety gains associated with automated decision aids in air traffic control.

The Aviation Medicine Office and the National Institute for Occupational Safety and Health (NIOSH) are examining cabin air quality issues and their effect on passengers and crew. Aviation Medicine is also developing bioengineering crite-

ria to support aircraft seat and restraint system certification, human performance and ergonomic data to support emergency evacuation regulations and standards, biomedical criteria to support protective breathing equipment and operational procedures certification, and biochemical and toxicological criteria supporting the use or certification of aircraft interior fire, smoke, and toxicity limits.

Program Area Structure

The programs address operational requirements through research in the technical thrust areas agreed to by the FAA, NASA, and DOD in the *National Plan for Civil Aviation Human Factors: An Initiative for Research and Application.*

Human-Centered Automation — This research focuses on the role of the operator and the cognitive and behavioral effects of using automation to assist humans in accomplishing their assigned tasks. The research in this area addresses the identification and application of knowledge concerning the relative strengths and limitations of humans in an automated environment. It investigates the implications of computer-based technology in the design, evaluation, and certification of controls, displays, and advanced systems.

Selection and Training — Research in this area strives to understand the relationship between human abilities and aviation task performance; enhances the measures and methods for the prediction of current and future job/task performance; establishes a scientific basis for the design of training programs, devices, and aids for individuals and teams; defines criteria for assessing future training requirements; and identifies new ways to select aviation system personnel.

Human Performance Assessment — Research in this area identifies intrinsic cognitive and decision making factors for individuals and teams which determine how well they are able to perform aviation tasks; characterizes the impact of environmental and individual factors on human performance; and improves and standardizes methods for measuring human performance.

Information Management and Display — Research in this area addresses the presentation and transfer of information among components in the NAS. It seeks to identify the most efficient and reliable ways to display and exchange information; determines what, when, and how one might best display and transfer information to system components; designs a system to reduce the frequency of information transfer errors and misinterpretations; and strives to minimize the impact when such errors do occur.

Bioaeronautics: Research in this area involves the bioengineering, biomedicine, and biochemistry associated with performance and safety. The objective is enhancement of personal performance and safety by maximizing crew and passenger protection, health, and physiological integrity. The program consists of three research initiatives:

1) Human protection and survival.
2) Medical and toxicological factors in accident investigation.
3) Support for aeromedical certification and in-flight aeromedical applications through aviation medicine program support.

Protecting humans in decelerative environments, protective breathing equipment, cabin evacuation, and water survival are investigated in the human protection and survival initiative. Toxicological assessment and sudden or subtle pilot incapacitation are key features of the accident investigation initiative. A program to survey the nature of in-flight medical emergencies, particularly the effectiveness of defibrillators carried on airlines, new vision corrective methods for aviation personnel, aircraft cabin environmental hazards, air ambulance medical requirements, and development of protocols for safe use of lasers in laser light shows to prevent incapacitation of pilots, represent current investigations under the aviation medicine program support initiative.

Customer/Stakeholder Involvement

The Human Factors Research Program:

The program directly supports a number of aviation community initiatives and Congressional mandates:

- FAA Strategic Plan Mission Goal for Safety: By 2007, reduce the US aviation fatal accident rate by 80% from 1996 levels. FAA will work with the aerospace community to:

  - Build on currently successful efforts to identify root causes of past accidents
  - Use a more proactive analytical approach, with new data sources, to identify key risk factors and intervene to prevent potential causes of future accidents
  - Study issues and technologies—in partnership with NASA, DOD, and other public and private organizations—to improve policies, procedures, and equipment.
- Office of the Associate Administrator for Research and Acquisitions Performance Plan, Goal 1 ("Contribute to the FAA goal to reduce the fatal aviation accident rate by 80 percent by 2007 as compared to 1994-1996 baseline data), and Goal 2 ("Ensure that human factors policies, processes, and best practices are integrated in the research and acquisition of 100 percent of FAA aviation systems and applications).
- Safer Skies — A Focused Agenda, will use the latest technology to help analyze US and global data to find the root causes of accidents and determine the best actions to break the chain of events that lead to accidents.
- *The National Plan for Civil Aviation Human Factors: An Initiative for Research and Application*, published in March 1995, with FAA, NASA, and DOD as signatories. This document, which had extensive aviation community participation in its development, outlines a coherent national agenda for human factors and bioaeronautical research and application leading to significant improvements in NAS safety and efficiency.
- The Aviation Safety Plan is supported through research addressing priority issues associated with crew training, collection and use of safety data, application of emerging technologies, and aircraft maintenance procedures and inspection. The Aviation Medicine program significantly contributes to the application of emerging technologies, as highlighted in the Plan.
- Implementation of the FAA report on "The Interfaces between Flight Crews and Modern Flight Deck Systems."
- Public Law 100-591, which establishes requirements for human factors research and its application as well as the Aviation Medicine Program to conduct research in (A) protection and survival of aircraft occupants; (B) medical accident investigation and airman medical certification; (C) toxicology and the effects of drugs on human performance; and (D) the impact of disease and disability on human performance.; the FY 1998 Department of Transportation Appropriations Act, which cites human factors as the greatest cause of aviation accidents and calls for high priority research; and The Aviation Safety Research Act of 1988, which requires that human factors research be conducted to "enhance air traffic controller performance, develop a human factors analysis of the hazards associated with new technologies, identify innovative and effective corrective measures for human errors, and develop dynamic simulation models of the ATC system."
- The RTCA "Free Flight Action Plan" specifically addresses recommendations to: establish more flexible decision support systems involving collaborative decision making; conduct human-in-the-loop simulations for assessing controller and pilot perceptions of hazards, risks, and discomfort; measure performance, workload, and situation awareness associated with controller and pilot responses to time and distance; conduct real-time human-in-the-loop simulations to systematically study controller and pilot behaviors, interactions, and effects within NAS environments that represent dynamic densities and sector configurations anticipated for free flight.
- Airline and aviation maintenance organizations provide access to their personnel and facilities to permit on-site, realistic research. These organizations have benefited from research products such as electronic job aids, intelligent tutoring systems, guidance on work site environmental conditions, shiftwork studies, and advanced training methods.
- The Aviation Medicine Program is responsible under DOT Order 8020.11A, Chapter.4, Paragraph 170 for conduct of toxicological analyses on specimens from, and special

pathologic studies on, aircraft accident fatalities.

- DOT Order 1100.2C, Chapter 53, Paragraph 53-15 requires that the Aviation Medicine Program investigate selected general aviation and air carrier accidents and search for biomedical clinical causes of accidents, including evidence of disease and chemical abuse.
- National Transportation Safety Board Safety Recommendations A-84-93 request the FAA establish at the Civil Aeromedical Institute the capability to perform state-of-the-art toxicological tests on the blood, urine, and tissue of pilots involved in fatal accidents to determine the levels of both licit and illicit drugs at both the therapeutic and abnormal levels.
- The Aviation Medicine Program is an integral participant and research provider under the FAA, Joint Aviation Authorities, and the Transport Canada Aviation Aircraft Cabin Safety Research Plan (established in 1995) which sets forth long-term research goals and ensures coordination between international aviation agencies. Programs within Aviation Medicine which study aircraft cabin environmental quality, and the nature and extent of in-flight medical emergencies are a direct result of specific Congressional mandates to study these topics.

Accomplishments

The Human Factors Research Program:

- Developed and field tested with several airlines a prototype Automated Performance Measurement System (APMS) which allows for gathering and analysis of data from aircraft flight data recorders. This information and analysis capability is utilized by the Flight Operations Quality Assurance program, a joint FAA and airline venture to enhance aviation safety.
- Validated use of simulator parameters and flight data for evaluating Advanced Qualification Program (AQP) effectiveness.
- Developed a model Advanced Qualification Program (AQP) for use by training centers to support regional air carrier participation in AQP, a proficiency-based approach to pilot training.
- Developed error mitigation training for cockpit crews.
- Developed human factors guidelines for air carrier use in constructing operating documents.
- Provided Crew Resource Management procedure guidelines for regional airlines.
- Validated human performance transfer functions for level B full flight simulators.
- Developed preliminary training guidelines for cockpit distractions and interruptions.
- Produced and presented the FAA Human Factors Course to increase understanding of the importance of considering the "human factor" in design/acquisition of FAA systems.
- Produced and distributed a handbook for Advanced Crew Resource Management training.
- Completed a study of the effectiveness of delivering technical information to line aircraft technicians using wireless, portable, pen-based computers that display technical publications.
- Initiated process to integrate shift-change error identification and mitigation processes into the aircraft maintenance error-detection and reporting system.
- Identified and documented best practices for engine non-destructive inspections and testing.
- Developed a process to improve work documentation in repair stations.
- Developed automated system of self instruction for specialized maintenance training.
- Developed pilot performance data through flight simulation for use in establishing certification standards for general aviation autonavigation and control systems.
- Completed human factors assessments of advanced controls and displays for the Advanced General Aviation Transport Experiment aircraft. Provided recommendations to guide certification of those devices

- Completed evaluation and recommendations for using PC-based aviation training devices in pilot instrument flight training
- Developed SATORI, a computerized system to graphically re-create ATC incidents in en route air traffic control. The technology has been transferred to each of the CONUS en route centers, the William J. Hughes Technical Center, regional offices, and headquarters.
- Validated and approved a new computerized test battery (AT-SAT) for operational use in selecting air traffic controllers.
- Validated the Basic Electronics Screening Tool for operational use in selecting electronics personnel.
- Directed a large-scale effort to identify and resolve a large number of human factors issues inherent in the STARS display.
- Sponsored the National Research Council's assessment of human factors issues in the air traffic control system and the publications entitled *Flight to the Future - Human Factors in Air Traffic Control* and *The Future of Air Traffic Control.*
- Conducted a human/system performance assessment of the Departure Sequencing Engineering Development Model.
- Completed a human factors audit of the Converging Runway Display Aid (CRDA) installed at St. Louis Airport. CRDA is a decision support tool that helps terminal radar controllers efficiently space aircraft arriving on separate, converging runways.
- Completed measurement of taskload and documented work processes of personnel at maintenance control centers.
- Developed guidelines to reduce in-flight sudden/subtle incapacitation.
- Evaluated autopsy data from fatal aviation accidents to recommend protective equipment and design practices.
- Assessed flight attendant reproductive health hazards.
- Reported on the suitability of component tests for showing regulatory compliance with crashworthiness standards for aircraft.
- Completed definitive evacuation escape slide angle and strength studies to minimize escape injuries and escape failures.
- Developed fit and comfort standards for aviation oxygen mask systems.
- Assessed operational hazards of in-flight laser exposure.
- Completed a study of DNA probes used in the identification of postmortem ethanol.

R&D Partnerships

The Human Factors Research Program:

The Human Factors Program is linked to NASA and DOD under the auspices of the *National Plan for Civil Aviation Human Factors: An Initiative for Research and Application.* Specific areas of coordinated program execution with NASA include cockpit automation, fatigue, crew resource management, team decision making, air-ground communication, and the Automated Performance Measurement System. DOD joint efforts involve fatigue, team performance, and decision making research. Additionally, the Human Factors Office maintains a membership in the DOD Human Factors Engineering Technical Advisory Group which provides a forum for the coordination of research across a variety of technical areas.

The Human Factors Office participates with the Netherlands National Research Laboratory in flight deck automation and air/ground integration research. The Office maintains an active membership on all Society of Automotive Engineering G-10 Human Factors subcommittees related to ongoing and future research areas to ensure transition of the results to standards and guidelines. Members from the National Transportation Safety Board work with the Human Factors Office in the areas of fatigue, flight deck automation, and error mitigation.

The Human Factors Office places grants with universities supporting research on air carrier training, flight deck automation, general aviation, and aviation maintenance technician training and air traffic/airway facilities. Coordinated research efforts are conducted with NASA Ames in free flight. An Interagency Agreement with the US Navy Air Warfare Center focuses on development

of training and performance measurement strategies to enhance teamwork in both flight deck crews and air traffic control teams. Special attention is being paid to training enhancements that develop aviation teamwork skills and the utility of advanced technologies for delivering team training. Additionally, elements of the controller performance research project are conducted in concert with the U.S. Air Force's Armstrong Laboratory. Finally, collaborative research in shift work and fatigue is conducted with the US Coast Guard Research and Development Center.

The Aviation Medicine Research Program:

The Office of Aviation Medicine collaborates with NIOSH on a study addressing the cabin environment and flight attendant and passenger symptomatology and diseases. In addition, a liaison is maintained with the American Society of Heating, Refrigeration, and Air Conditioning Engineers Committee addressing aircraft cabin air quality status and research.

The Office of Aviation Medicine maintains direct cooperative research processes with all the manufacturers responsible for safety products (seats, restraint systems, oxygen masks, evacuation slides, etc.). The Office of Aviation Medicine is also represented on appropriate subgroups of organizations such as the Aerospace Medical Association, the Society of Automotive Engineers, the Civil Aviation Medical Association, and the Professional Aeromedical Transport Association. Appropriate liaison with the military is maintained either through direct project collaboration (e.g., crashworthiness, eye injury from lasers) or through more global participation in the Tri-Services Aeromedical Research Panel, and the North American Treaty Organization (NAT0) Aerospace Medical Advisory Group.

Long-Range View

The Human Factors Research Program:

The FAA has accepted national responsibility to initiate and maintain research and development programs that support modernization, regulation, certification, and NAS issues, and, with equal importance, national responsibility to initiate research which is proactive in identifying emerging safety trends. The Human Factors investment strategy will directly support proactive research efforts to identify and address targeted safety issues.

Baseline data will be established to show direct causal relationships between research outputs and accidents and incidents. Research programs will be directed at targets that have the greatest impact on aviation safety, will be multi-year efforts, and require stabilized resources to plan, execute, and complete. Successful implementation of research outputs will require full partnerships and close cooperation within FAA organizations and the aviation community.

Research strategies will focus on technology, partnerships, and measurements. For example, methods will be developed to identify interventions to address human performance issues in aviation maintenance and air traffic operations. With regard to partnership strategies, a five-year integrated safety research plan will be developed with NASA, addressing long-range, high pay-off priorities. Measurement strategies will be developed to accurately monitor trends and identify opportunities for research to mitigate risks.

Public and Congressional interest in the maintenance of a healthy and comfortable environment for each category of civil aviation's participants is not abating. The five-year interagency agreement between FAA and NIOSH initiated in FY97 addresses infectious disease and other health considerations in the aircraft cabin environment.

FAA goals related to preventing accidents and minimizing injury, associated pain, necessary rehabilitation, and death as a consequence of aviation accidents make the work of the Aviation Medicine Program a critical component of coordinated steps which will increase human survivability, which is one of the accepted corporate strategies for decreasing fatality accidents. The Aviation Medicine program will emphasize the reduction of accidents, and reduction in the severity of injuries encountered in such precautionary events as evacuation of passengers from an aircraft after recognition of a safety concern by the flight crew. This approach will cut rehabilitation time, decrease medical costs, and improve the quality of life for those who suffer injuries.

Additionally, in concert with the targets expressed in Challenge 2000 and with FAA's

broad commitments to harmonize safety regulations on a global scale, the Aviation Medicine Program will focus its collaborative interactions with domestic and international laboratories to generate research data to be used in the development of internationally harmonized aviation standards and regulations. Aeromedical research will be increasingly required to interpret data derived from around the world, and to assess whether the data are appropriate or require additional investigation prior to use in regulatory or other actions.

A08a Flight-Deck/Maintenance/System Integration Human Factors

GOALS:

Intended Outcomes: The FAA intends to improve air transportation safety by:

- Developing more effective methods for aircrew, inspector, and maintenance technician training.
- Developing more human-centered flight controls and displays.
- Increasing human factors considerations in certification of new aircraft and equipment design and modification.
- Improving aircrew, inspector, and maintenance technician task performance.

Agency Outputs: The FAA is concerned with ensuring the safety and efficiency of operator performance through guidelines, handbooks, advisory circulars, rules, and regulations. It provides industry with human performance information and guidance critical to the design, operation, regulation, and certification of equipment, training, and procedures. The Human Factors Program conducts and manages research that provides the technical information necessary to generate these products and services.

Customer/Stakeholder Involvement: The Human Factors Program directly supports a number of aviation community initiatives:

- *FAA Strategic Plan Mission Goal for Safety.* By 2007, reduce U.S. aviation fatal accident rates by 80% from 1996 levels; ARA FY 2000 Performance Plan:
  - Goal 1. Contribute to the FAA goal to reduce the fatal aviation accident by 80% by 2007 as compared to 1994-1995 baseline data; and
  - Goal 2. By 2005, ensure human factors policies, processes, and best practices are integrated in the research and acquisition of 100 percent of FAA aviation systems and applications.
- The FAA/Industry *Safer Skies* initiative, which will use the latest technology to help analyze US and global data to find the root causes of accidents and determine the best actions to break the chain of events that lead to accidents.
- The *National Plan for Civil Aviation Human Factors: An Initiative for Research and Application* published in March 1995, with FAA, NASA, and DOD as signatories. This document, which had extensive aviation community participation in its development, outlines a coherent national agenda for human factors research and application leading to significant improvements in NAS safety and efficiency.
- The FAA report entitled "The Interfaces Between Flight Crews and Modern Flight Deck Systems."
- Public Law 100-591, which establishes requirements for human factors research and its application.
- The Advanced Qualification Program (AQP), which has been adopted by every major US carrier, incorporating human factors training into pilot qualification and recurrent training programs.
- Crew Resource Management (CRM) training procedures, a variant of which has been adopted by virtually every major domestic air carrier.

Accomplishments: The program output of data packages, models, and regulatory documents include:

- Developed, and currently field-testing with several airlines, a prototype Automated Performance Measurement System (APMS) which allows for the gathering and analysis of data from aircraft flight data recorders. This information and analysis capability provides the backbone for the Flight Operations Quality Assurance Program, a joint FAA and airlines venture to enhance aviation safety.
- Provided proceduralized CRM guidelines for major and regional airlines.
- Validated human performance transfer functions for level-C full flight simulator.
- Developed a model AQP to support regional air carrier participation. AQP is a proficiency

based approach to pilot training that is considered to be highly effective and efficient for aircrew training.

- Developed the AQP database, incorporating user comments on the task analysis and task listing components, and incorporated a performance database which will link tasks to performance indicators.
- Provided air carrier training data analysis tools for quality assurance.
- Developed a system to allow air carriers to reconfigure FAA-approved flight scenarios to unique training segments, and developed a generic line-oriented evaluation event set database to be used by any air carrier.
- Developed a set of requirements for simulator motion for recurrent training.
- Initiated a comprehensive research program addressing cockpit automation.
- Developed a prototype certification Job Aid for FAR Part 25 flightdeck displays. This tool will be used by certification personnel and designers to address human performance considerations during the aircraft certification process.
- Published the *Aviation Maintenance Human Factors Guide.*
- Developed and implemented the Agency's first virtual collaborative research team to communicate and disseminate information in real time regardless of distance or other constraints on research team members.
- Developed (with industry) the first industry standard and guidance document on implementing an Aviation Maintenance Human Factors Program.
- Completed the Job Task Analysis of the Aviation Maintenance Technician Workforce.
- Developed the Aviation Maintenance Document Design Aid incorporating simplified English and utilizing advanced technology to standardize aviation maintenance documentation.
- Developed the Maintenance Resource Management (MRM) handbook for use by industry.
- Completed the prototype MRM distance learning project which will be implemented and used by the US Navy for training their Naval Aviation Maintenance Technicians. Further application can be applied to US Coast Guard Aviation Maintenance Technicians.
- Developed an Advisory Circular on Training, Qualification, and Certification on Nondestructive Inspection Personnel.
- Developed a prototype automated system of self-instruction for specialized training for the industry aviation maintenance inspector workforce.
- Developed guidance and recommendations on human factors best practices in fluorescent penetrant inspection. This project provided a more systematic view of human/system interaction.
- Developed guidance and standardized shift turn-over procedures for use in aviation maintenance.
- Provided educational outreach to the aviation community through the NASA/FAA fatigue countermeasures training module.
- Developed pilot performance profile, through flight simulation, for use in establishing certification standards for General Aviation autonavigation and control systems.
- Developed aircraft certification human factors and operations checklist for stand alone global positioning system receivers.
- Developed a CD-ROM training program that guides General Aviation pilots through the creation of a personal checklist that incorporates minimum operating conditions and procedures based upon their own personal capabilities and experience.
- Developed a CD-ROM training program which describes the structured decision-making style of experienced General Aviation pilots compared to less experienced pilots. The program stresses situational awareness, diagnosis, resolution, and vigilance.
- Developed a CD-ROM training program which teaches General Aviation pilots to rec-

ognize the cues associated with deteriorating weather while in-flight, and to take appropriate action to avoid weather.

R&D Partnerships: Collaboration has continued between the FAA and industry partners to develop intervention strategies and reduce aviation accidents through the various Joint Safety Awareness Teams (JSATs) developed as part of the Safer Skies agenda. The human factors program is linked to NASA and DOD under the auspices of the *National Plan for Civil Aviation Human Factors: An Initiative for Research and Application.* Specific areas of coordinated program execution with NASA include cockpit automation, fatigue, CRM, team decision making, air- ground communication, and aviation maintenance. DOD joint efforts are in fatigue, team performance, decision making, aviation MRM, distance learning, and human error risk analysis. Additionally, the FAA is represented on the DOD Human Factors Engineering Technical Advisory Group, a forum for the coordination of research across a variety of technical areas. Members from the National Transportation Safety Board (NTSB) provided input to the human factors program in the areas of fatigue, flight deck automation, error mitigation, and aviation maintenance. Through aviation maintenance partnerships with industry, the FAA and industry are receiving real world applied research results. Aviation maintenance human factors is also working with other countries (such as Transport Canada) for globalization of aviation maintenance and inspection human factors. The FAA participates on all of the Society of Automotive Engineers G-10 human factors subcommittees related to human factors research areas, ensuring transition of the results to standards, guidelines, etc. The FAA also has extended grants to sixteen universities supporting research on air carrier training, flight deck automation, general aviation, and aviation maintenance technician and inspector training.

MAJOR ACTIVITIES AND ANTICIPATED FY 2000 ACCOMPLISHMENTS:

Selection and training.

- Provided industry and the FAA guidance addressing training crewmember use of advanced automated systems.
- Provided methods to integrate quantitative indices of operational performance data with pilot training data to evaluate the effectiveness of flight training programs, specifically AQP.
- Provided methods of employing scenario-based evaluation and analysis techniques to identify troublesome trends before accidents occur, and provide appropriate training technologies to remediate identified weaknesses.

Human performance assessment.

- Provided expanded APMS methodologies and analysis capabilities in order that air carriers can collect and analyze increasing amounts of flight and simulator data.
- Developed mapping of flight data parameters onto AQP qualification standards.
- Developed Human Factors Guidelines for Certification of Head-up Display for Air Transports, version 1.
- Provided initial pilot/controller shared separation performance requirements for Free Flight.
- Completed assessment of the utility of PC-based aviation training devices in maintaining General Aviation pilot instrument proficiency.
- Completed evaluation of the application of a comprehensive human factors analysis and classification system (HFACS) to air carrier and general aviation accidents.

Human-centered automation.

- Provided industry and FAA guidance addressing training for automated cockpits. These guidelines will encompass the performance difficulties associated with increased coupling, complexity, and autonomy of modern cockpit technology.
- Completed human factors certification Job Aid version 1 for FAR Part 25 flightdeck displays. This tool will be used by certification personnel and designers to address human performance considerations during the aircraft certification process.
- Completed human factors guidelines for assessing advanced general aviation transporta-

tion experiments (AGATE) cockpit controls/ displays.

Information management and display.

- Completed software tools for enhanced maintenance documentation.
- Developed preliminary version of Electronic Flight Bag usability evaluation tool.
- Developed General Aviation head-up display information/symbology recommendations.
- Completed Data Link lessons-learned compendium for inclusion in RTCA DO-238A, "Human Factors Requirements and Guidance for Controller/Pilot Data Link Communications Systems".
- Completed prototype human factors guidelines for the certification of head-up displays for air transports.

KEY FY 2001 PRODUCTS AND MILESTONES:

Selection and training.

- Report on antecedents to cockpit error in air carrier operations.
- Develop training guidelines for multi-tasking activities related to cockpit distractions.
- Survey results of air carrier pilots addressing AQP training effectiveness.
- Report on automated skills leading to training guidelines for automated cockpits.
- Draft prototype integrated CRM technical training program based on model AQP methodology.
- Develop training guidelines for air carrier pilot decision-making, addressing first officer's hesitancy to challenge the captain in potentially high risk situations.
- Produce modified reconfigurable event set scenario development system.

Human performance assessment.

- Refine flight and simulator data analysis tools.
- Report on the effectiveness of realistic radio communications in line-oriented evaluations.
- Define General Aviation pilot decision-making skills required for training module development.
- Provide expanded APMS methodologies and analysis capabilities in order that air carriers can collect and analyze increasing amounts of flight and simulator data.
- Develop improved human factors guidelines for aircraft accident investigation and reporting systems.

Human-centered automation.

- Provide industry and the FAA guidance addressing training for automated cockpits. These guidelines will encompass the performance difficulties associated with increased coupling, complexity, and autonomy of modern cockpit technology.
- Provide human factors evaluation for AGATE flight systems configurations.
- Develop certification guidelines for integrated technology in general aviation cockpits.
- Complete human factors certification Job Aid version 2.0 for FAR Part 25 flightdeck displays. This tool will be used by certification personnel and designers to address human performance considerations during the aircraft certification process.

Information management and display.

- Develop and implement guidelines for maintenance error investigating and reporting systems.
- Develop flight data recording and analysis capability for flight simulators.
- Complete Electronic Flight Bag usability evaluation tool.
- In response to the evolving requirements of AGATE, conduct comparative analyses to determine if any substantial degradation in visual search is concurrent with the presence and/or use of the head-up or head-down display, and which tasks benefit most from each type of presentation.

- Complete human factors guidelines for the certification of head-up displays for air transports.

FY 2001 PROGRAM REQUEST:

The program continues to focus on providing technical information and consultation to improve aircrew, inspector, maintenance technician, and aviation system performance. Emphasis is on developing guidelines, tools, and training to enhance error capturing and mitigation capabilities in the flight deck and maintenance environments; and on developing human factors tools to ensure that human performance considerations are adequately addressed in the design and certification of flight decks and equipment.

A08a - Flight-Deck/Maintenance/System Integration Human Factors Product and Activities	FY 2001 Request ($000)	Program Schedule					
		FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY2005
081-110 Flightdeck/Maintenance/System Integration Human Factors							
Selection and Training	$2,600						
Provide Methods to Integrated Performance Data with Pilot Training Data to Evaluate Flight Training		◆	◇	◇			
Develop Advanced Qualification Program (AQP) Database Incorporating User Comments		◆	◇	◇	◇	◇	
Provide Air Carrier Training Data Analysis and Tools Tailored to Scenario-Based Evaluation		◆	◇	◇	◇	◇	◇
Provide Industry and FAA Guidance Addressing Training Crewmember Use of Advanced Automated Systems		◆	◇	◇	◇	◇	◇
Report on Antecedents to Cockpit Error in Air Carriers		◆	◇				
Implement Advanced GA Training Techniques		◆	◇	◇	◇	◇	◇
Completed Guidelines for Maintenance Technician Situation Awareness Training		◆					
Human Performance Assessment	$700						
Provide Expanded Automated Performance Measurement System (APMS) Methodologies and Analysis to Collect/ Analyze Flight/Simulator Data		◆	◇	◇	◇	◇	◇
Develop Guidelines for Certification of Head-Up Displays		◆	◇	◇			
Develop Guidelines for Accident Investigation and Reporting		◆	◇				
Complete Research on Aviation Maintenance Error Reporting Systems		◆	◇	◇			
Human Centered Automation	$2,368						
Initiate/Coordinate Comprehensive Research Program Addressing Cockpit Automation		◆	◇	◇	◇		
Provide Preliminary Recommendations for Improved Training for Automated Flight Management Systems		◆	◇	◇	◇	◇	
Develop a Job Aid to Help Certification Personnel and Designers Assess Automated Flight Decks		◆	◇	◇			
Provide Industry and FAA Guidance Addressing Training for Automated Cockpits		◆	◇	◇	◇	◇	◇
Provide Industry and FAA Guidance to Effectively Address Cultural Influence on Crewmember Use of Automated Systems		◆	◇	◇			
Provide Human Factors Evaluation for Advanced General Aviation Transport Experiment (AGATE) Flight Systems		◆	◇				
Information Management and Display	$1,145						
Complete Software for Enhanced Maintenance Documentation		◆	◇				
Develop and Implement Guidelines for Maintenance Error Investigation and Reporting Systems		◆	◇	◇			
Complete Electronic Flight Bag Usability Evaluation Tool		◆	◇				
Develop Guidelines for Design/Certification of Head-Up Display for General Aviation		◆	◇	◇	◇		
Personnel and Other Costs	$3,287						
Total Budget Authority	$10,100	$9,142	$10,100	$10,323	$10,600	$10,934	$11,330

Note: Out year numbers are for planning purposes only. Actual funding needs will be determined through the annual budget process.

Budget Authority ($ in Thousands)	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Enacted	FY 2001 Request
Contracts	8,430	10,365	8,497	6,289	7,038
Personnel Costs	2,048	1,814	1,940	2,367	2,283
Other Costs	420	371	563	486	779
Total	10,898	12,550	11,000	9,142	10,100

A08b Air Traffic Control/Airway Facilities Human Factors

GOALS:

Intended Outcomes: The FAA intends to:

- Address today's human factors problems associated with National Airspace System (NAS) transition and operational integration of decision support and other automation.
- Increase understanding of the human factors of emerging technologies, changing human roles and responsibilities, and evolving procedures, to help optimize human performance.
- Promote integration of human factors products into the development of advanced operational concepts that are based upon transitions in the NAS architecture.
- Develop enhanced measures of human performance and increase understanding of factors which can lead to performance decrements.
- Develop intervention and management strategies for fatigue and error.

Agency Outputs: Human factors problems in today's operations involve human performance considerations and human factors issues in the acquisition of Air Traffic Control (ATC) systems. The study of the relationship between shiftwork schedules and fatigue is identifying techniques for mitigating impacts on controller performance. Taxonomic analysis of operational errors is identifying improvements in how errors are investigated and reported, which in turn is leading to more effective interventions. Human factors research provides guidelines and other information for the design and development of ATC systems and product improvements. Research products are shared with the aviation community via the World Wide Web. Research and development products include:

- Models of performance and efficiency based on system variables.
- Development of workload, performance, and decision-making measures and models for existing systems and new technologies.
- Human/system productivity enhancement technology.
- Tests and criteria for selecting operational personnel.
- Recommendations for the design of operational facilities and control rooms.
- Guidelines and recommendations for minimizing sources of error and fatigue.

Customer/Stakeholder Involvement: The ATC/Airways Facilities (AF) Human Factors Research Program is the product of continued cooperation and collaboration between the Office of the Chief Scientific and Technical Advisor for Human Factors (AAR-100) and its customer base, the Air Traffic Requirements Service (ARS). Details of the research portfolio are coordinated with the following organizational elements of ARS: Plans and Performance Directorate (ARX-20); Resource Management Program (AFZ-100); NAS Operations (AOP-30); and Air Traffic Procedures (ATP-400). In addition, organizational elements of the Office of Communication, Navigation, and Surveillance Systems (AND), and the Office of Air Traffic Systems Development (AUA) share in research planning through the medium of AAR-100 representatives which reside within those organizations. Also represented is the Offfice of System Architecture and Investment Analysis (ASD-130) which offers input and with whom research projects are frequently coordinated.

Human Factors research is grounded in the human factors issues that emerge from FAA's ongoing transition to new concepts of operation. The 2005 Concept of Operations states: "the NAS in 2005 takes a human-centered approach to maximize the efficient delivery of air traffic services to users. Thus, system processes and workstations are designed to expedite the exchange of information between NAS information systems, service providers, and users. Human factors analyses and human-in-the-loop simulations have determined the appropriate allocation of tasks between service providers, users, and automation systems. Moreover, issues such as situation awareness, workload, and computer-human-interface (CHI) design have been resolved by incorporating human factors. This approach ensures that the human capabilities and limitations of users and service providers remain a primary consideration in systems development. The evolution of the NAS utilizes a clear transition strategy for each opera-

tional capability, and employs a human-centered approach for implementing new operational concepts and supporting technologies".

The program also draws on NAS Architecture Version 4.0 which specifies: "a broad range of research activities regarding the implications of human factors. These research activities will acquire and then apply the information necessary to understand human capabilities and limitations in each functional area. Human factors engineering will then be applied to identify and resolve risks, and to assess costs, benefits, and trade-offs".

The ATC/AF Human Factors Research Program is also responsive to the recommendations of the congressionally mandated Research, Engineering, and Development Advisory Committee (REDAC). Among REDAC recommendations are suggestions to "Increase emphasis on understanding the implications of various Free Flight architectural alternatives on pilot and controller performance, and incorporate this understanding early in the NAS architecture evolution process". Some of the human performance issues that appear to be important to "Free Flight" and are factored into planning the research portfolio include:

- Distribution of Air/Ground responsibility.
- Strategies and technologies used by controllers to organize traffic.
- Ability of controllers to deal with flexible airspace (e.g., dynamic resectorization).
- Monitoring and out-of-loop issues for pilots and controllers.
- Trust in automation.
- Conflict resolution strategies.
- Collaborative decision making behavior.
- Gaming behavior on the part of pilots, airlines and controllers.
- Shared situational awareness.
- Intervention strategies.
- Communication requirements.
- New strategies for error assessment in a collaborative environment.

In addition, research planning is directly tied to the following ARA Performance Goals:

Goal 1. Safety: In support of the FAA's mission goal related to system safety, contribute to the FAA goal to reduce the fatal aviation accident rate 80% by FY 2007 as compared to 1994-1996 baseline data.

Goal 2. Human Factors: In support of FAA's performance goals, ARA will, by 2005, ensure human factors policies, processes, and best practices are integrated in the research and acquisition of 100 percent of FAA aviation systems and applications. Two strategies have been identified to ensure that human factors are addressed in the research and acquisition of 100% of FAA aviation systems and applications. These strategies cover human factors activities associated with the study, analysis, research, design, development, testing, deployment, and implementation of FAA systems and applications.

Central to this research program, as well as other research efforts conducted by AAR-100, is its emphasis on the *National Plan for Civil Aviation Human Factors: An Initiative for Research and Application*. This document, published in March 1995, with FAA, NASA, and DOD as signatories, had extensive aviation community participation in its development, and outlines a coherent national agenda for human factors research and application leading to significant improvements in NAS safety and efficiency.

Accomplishments: The program has performed or sponsored the following research with resulting products:

- Developed database of air traffic control performance measures.
- Basic Electronic Specialist Test (BEST) - Improved screening test for selection of AF new hires, with an estimated savings of $3-5 million/year in reduced training costs.
- Variable Item Generator (VIGOR) – This enhances the reliability of the BEST test by mitigating coaching or practice effects.
- Post Operations Evaluation Tool (POET) – Developed a software product that contributes to ATM collaborative decision-making.

- Flight Service Station Operational and Supportability Implementation System (OASIS) Study – Conducted virtual reality ergonomic evaluation of proposed Flight Service Station workstations.
- Database of Air Traffic Control Specialist (ATCS) Field Work Schedules – Completed first element of Congressionally mandated study of controller shiftwork, fatigue, and performance.
- Enhanced Visual Scanning Methodology - Adapted technology for integration with the 2005 Concept of Operations simulation studies.
- Impact of Shared Separation on ATCS Situation Awareness – Conducted study of free flight impact on air traffic controllers' performance.
- Guidelines on use of Color in ATC Displays – This provides Integrated Product Teams (IPTs) with reference information on the most effective uses for color in new system displays.
- Future Controller Selection – Developed prototype methodology to evaluate the impact of technological and Concept of Operations change on controller selection requirements.
- Auditory Alarm Database – Developed extensive database of alarms applicable to the design of alerting systems for AF in future centralized maintenance and control centers.
- Aviation Safety Reporting System Pilot-Controller Communications – Prepared analysis of data concerning occurrences of pilot-controller miscommunication.
- Multi-sector ATC Teamwork Simulator - Developed and delivered to the FAA Academy for use in Air Traffic Team Enhancement Program (ATTEP).
- Standard Terminal Automation Replacement System (STARS) - Conducted comprehensive assessment of the STARS operational radar display and maintenance control workstations. Identified a significant number of human factors issues which were resolved through a work group comprised of human factors, ATS, STARS program office, NATCA, Raytheon, Mitre and other stakeholders. A notable product was a definitive process to integrate human factors in other NAS acquisitions.
- Air Traffic Controller Selection - Collaborated with ATS to develop new selection instrument for air traffic controllers.
- National Research Council (NRC) Study - Sponsored the NRC assessment of human factors issues in the air traffic control system. Under this grant, the NRC briefed the FAA and Congress and published two books, *Flight to the Future - Human Factors in Air Traffic Control*, and T*he Future of Air Traffic Control.*
- Systematic Air Traffic Operations Research Initiative (SATORI) - Completed development of enroute SATORI, a research and accident investigation tool installed in all Air Route Traffic Control Centers.
- Airway Facilities Maintenance Study - For the Airway Facilities Operations Management Team, measured taskload and documented work processes of personnel at present Maintenance Control Centers (MCCs).

R&D Partnerships:

NASA, DOD, and FAA are cooperative partners in the development and execution of *the National Plan for Aviation Human Factors: An Initiative for Research and Applicatio*n. Coordinated research efforts are conducted with NASA Ames in the areas of free flight and shift work induced fatigue and associated countermeasures. Additionally, elements of the controller performance research project are conducted in concert with the USAF's Armstrong Laboratory and the US Coast Guard R&D Center. Internationally, research on development and validation of controller applicant selection methods is shared between project leaders in this program and their functional equivalents in Sweden, Denmark, Australia, Great Britain, and other EUROCONTROL countries.

MAJOR ACTIVITIES AND ANTICIPATED FY 2000 ACCOMPLISHMENTS:

- Congressionally mandated assessment of the minimum English language proficiency required of controllers in other countries.
- High-fidelity computational models of human performance with larger scale models of NAS operation.
- Comprehensive database of ATC performance baselines and metrics.
- Report on the impact of dynamic airspace restructuring on air traffic controller performance.
- Report on workload issues associated with conflict probe.
- Assessment of the impact of conflict probe and Controller-Pilot Data Link Communications on Air Route Traffic Control Center sector team performance.
- Taskload and performance measurement pre- and -post Display System Replacement (DSR) implementation.
- Assessment of air traffic controller separation strategies.
- Initial results of using bright lights as a fatigue countermeasure.
- Strategic job analysis determining changes in controller knowledge, skill, and abilities associated with emerging technologies.
- Strategies for human error prevention/mitigation in AF maintenance control centers.
- Identification of impacts of alternative work schedules on controller performance.
- Enhanced capability to recreate operational incidents using recorded data from the DSR.
- Benchmarking of best practices and lessons-learned regarding implementation of enterprise asset management systems for Airway Facilities.

KEY FY 2001 PRODUCTS AND MILESTONES:

Research to be conducted will impact a wide variety of ATS programs. To facilitate understanding, these efforts are grouped into the following research thrusts previously identified in the National Plan:

Information Management and Display

- Reduction of paper flight progress strips. Refinements to automation, procedures and training to facilitate reducing the operational need for paper flight progress strips will be developed.
- Resolving human factors issues in controller/pilot data link communications. Information coding techniques for enhanced future ATS displays will be examined.
- Use of color in ATC alerting. Efficacy of display coding techniques for information alerting will be explored.
- Information management in future AF systems. The goal of this task is to determine how to optimize information transfer and display to support operator and team performance in the AF environment.
- ATC emulation prototypes and simulator development. The FAA is fielding STARS and the DSR to modernize the terminal and en route air traffic control systems. These systems will provide the infrastructure for future ATC functionality and advanced ATM concepts. The FAA is developing emulation prototypes of each of these systems. These prototypes will provide a rapidly reconfigurable environment to demonstrate advanced ATC concepts and functionality. Further, the prototypes will be integrated with the existing Target Generation Facility to provide a high fidelity simulation environment to operationally validate concepts and conduct essential ATC research for NAS modernization.
- Update of Human Factors Design Guide (HFDG). This update of the HFDG includes integrating newer scientific design information for the computer-human interface, automation, and other sections.
- Identification and display of ATC complexity factors. Develop graphic displays of factors related to ATC complexity. Simulation studies with ATCSs will be conducted to assess the effectiveness of proposed display designs.

Human Centered Automation

- Controller Decisionmaking. Baseline measures of controller decisionmaking will be developed and evaluated. Alternative methods for displaying decision support information will be assessed.
- Situational awareness in centralized monitor and control. This research will determine what information and feedback is necessary for the operators to stay aware of automated processes and what implications the changing technology will have on situational awareness, workload, and performance.
- Conflict probe study. This project will use human-in-the-loop simulation to investigate how human operators use conflict probe tools in enroute airspace.

Human Performance and Assessment

- Human performance modeling integration. This research will integrate high-fidelity computational models of human performance with larger scale models of NAS operation, and will leverage data from human-in-the-loop simulation studies.
- Error mitigation. The goal of this research is to identify potential sources of human error and investigate strategies to mitigate their occurrence or severity.
- POWER taskload and performance baseline assessments. A set of numerical measures based on available recorded radar data will be developed to assess controller taskload as well as controller and system performance. The resulting measures will be used to baseline levels of taskload and performance at en route facilities. Data for facilities receiving DSR in this time frame will be collected and analyzed to compare taskload and performance before and after DSR implementation.
- Flight Planning. This research makes a detailed account of the opportunities and requirements for, and constraints upon collaborative decisionmaking about the filing and rerouting of flight plans for commercial aircraft.
- Boundary adjustment research. This study will apply real time human-in-the-loop simulation to examine these issues. Current enroute controllers will participate in this study.
- Traffic demand prediction. This initiative will document information requirements for predicting traffic demand for sectors, and ascertain and document the information a Traffic Management Specialist needs, the sources of that information, and corollary knowledge used to make accurate predictions of traffic demand.
- Team processes in centralized monitor and control systems. This task will evaluate team and organizational concepts for relevance to AF. The result will be AF guidelines to enhance effective team operations in centralized monitor and control environments.
- Understanding expert ATC performance. This project will apply techniques from research on expertise to the ATC domain. Models of ATC performance, as well as objective metrics of cognitive performance, will be developed from this research. The objective measures will be applied to baselining performance in the current system and providing a knowledge base for optimizing transition to future systems. In addition, the FAA will identify opportunities to enhance cognitive performance in training.
- Baseline assessment of ATC teamwork and collaborative decision making. This project focuses on developing baseline information on coordinated decision making for the R-side and D-side controllers in the en route environment, and for terminal radar approach controllers.
- Examination of causal factors related to situational awareness. This project is targeted at reducing operational errors and deviations through the understanding of causal factors.
- Shift work and fatigue. This research is designed to evaluate the effectiveness of specific countermeasures for preventing shift work-related fatigue. The interaction of fatigue with age will be investigated.
- Human factors brochure for controllers. This brochure will provide controllers with helpful information about human factors they can use to enhance on the job performance.

- Complete DSR revisions of SATORI. SATORI enhancements are needed to read and analyze DSR recorded data.

Selection and Training

- Develop and validate computerized application evaluation systems. These systems will provide a tool for evaluating large number of applicants quickly and efficiently against qualification standards.
- Develop and validate computer-based selection tests. This project entails developing technical refinements to and conducting longitudinal validations of prototype modular, computer-based selection tests for near-term hiring into the ATCS, Electronic Technician, and Air Traffic Service Specialist occupations.
- Develop a prototype workforce analysis application. This tool will support the identification, description, and analysis of gaps between current and future workforce knowledge, skills, and abilities, and staffing profiles in the NAS architecture.

FY 2001 PROGRAM REQUEST:

The FY 2001 research program reflects a heightened emphasis on working with ATS to more fully address the pressing human factors issues that pose operational and maintenance risks for successfully fielding new technologies and procedures (such as Free Flight and Airway Facilities Operational Control Centers) over the next several years. Research projects focus on providing timely information to answer critical human factors questions associated with how these new systems and procedures will change human roles and responsibilities and consequent baseline changes to workload, situation awareness, error, and other performance attributes. Human factors research will ensure that human performance within this ever evolving and increasingly complex NAS is continually optimized to ensure effective human-system integration.

A08b - Air Traffic Control/Airway Facilities Human Factors Product and Activities	FY 2001 Request ($000)	Program Schedule					
		FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY2005
082-110 Air Traffic Control/Airway Facilities Human Factors							
Selection and Training	$670						
Develop/Validate Computerized Application Evaluation Systems		◆	◇				
Develop/Validate Computer-Based Selection Tests		◆	◇	◇			
Develop Prototype Workforce Analysis Application		◆	◇	◇			
Human Performance Assessment	$1,000						
Research Boundary Adjustment		◆	◇	◇	◇	◇	
Integrate Human Performance Modeling		◆	◇	◇	◇	◇	◇
Team Processes in Centralized Monitor/Control Systems		◆	◇	◇			
Mitigate Errors		◆	◇	◇	◇	◇	◇
Predict Traffic Demand		◆	◇	◇	◇	◇	◇
Display System Replacement (DSR) of Systematic Air Traffic Operations Research Initiative (SATORI)		◆	◇				
Effects of DSR Implementation and Transition Training		◆	◇	◇	◇		
Shift Work and Fatigue		◆	◇	◇	◇		
Baseline Assessment of Air Traffic Control (ATC) Teamwork/ Collaborative Decision-Making		◆	◇	◇			
Human Centered Automation	$1,300						
Situational Awareness in Centralized Monitor/Control		◆	◇	◇			
Controller Decision-Making		◆	◇	◇	◇		
Identification and Display of ATC Complexity Factors		◆	◇	◇	◇		
Conflict Probe Study		◆	◇	◇	◇		
Controller/Aircraft Separation Strategies		◆	◇	◇	◇	◇	◇
Information Management and Display	$1,275						
Information Management in Airway Facility Systems		◆	◇	◇	◇	◇	◇
Reduction of Paper Flight Progress Strips		◆	◇	◇	◇		
Information Coding Techniques for Enhancement of Future Air Traffic System (ATS) Displays		◆	◇	◇	◇	◇	◇
Efficacy of Display Coding Techniques for Information Alerting		◆	◇	◇			
Personnel and Other Costs	$5,705						
Total Budget Authority	**$9,950**	**$8,000**	**$9,950**	**$10,293**	**$10,678**	**$11,112**	**$11,595**

Note: Out year numbers are for planning purposes only. Actual funding needs will be determined through the annual budget process.

Budget Authority ($ in Thousands)	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Enacted	FY 2001 Request
Contracts	4,356	5,454	5,711	1,661	4,245
Personnel Costs	3,258	3,773	3,117	5,034	3,984
Other Costs	722	773	1,172	1,305	1,721
Total	8,606	10,000	10,000	8,000	9,950

A08c Aeromedical Research

GOALS:

The FAA safety mission dictates that:

- Existing injury and death patterns in civilian aviation accidents be meticulously reviewed.
- Recommendations for protective equipment and procedures be developed.
- Options be evaluated on behalf of FAA regulatory and medical certification staff charged with the proposal of safety regulations addressing all aircraft cabin occupants.

A concurrent mission is the identification of pilot, flight attendant, and passenger medical conditions that are incompatible with in-flight clinical and physiological demands on the occupant, both in the absence and presence of emergency flight conditions.

Intended Outcomes: The outcomes addressed by this research program are improved health, safety, and survivability of aircraft passengers and aircrews. This research program identifies human failure modes (physiological, psychological, clinical) both in uneventful flight, and during aircraft incidents and accidents. Formal recommendations for counteracting measures and techniques are derived from in-house research.

The FAA is able to develop new and evaluate existing bio-aeronautical guidelines, standards, and models for aircraft cabin equipment, procedures, and environments as a base for new regulatory action and the evaluation of existing regulations to enhance appropriate human performance at a minimum cost to the aviation industry. By reviewing pilot medical histories, flight histories, information from accidents and incidents, and existing/ new medical criteria, standards and assessment/ certification procedures can be proposed to ensure full performance capability at a minimal cost to the aviation industry. By assessing flight attendant and passenger environmental, behavioral, and disease issues, guidelines for actions to improve the health and safety of the aircraft occupant can be rationally proposed.

Agency Outputs: The program has developed the following criteria for use in regulatory and certification processes:

- Quantitative bioengineering criteria to support aircraft seat and restraint system certification.
- Quantitative biomedical criteria to support protective breathing equipment and operational procedures certification.
- Quantitative biochemical and toxicological criteria supporting the use or certification of aircraft interior fire, smoke, and toxicity limits.
- Quantitative biomedical criteria to support flotation and onboard rescue equipment certification.
- Identification of medical/toxicological factors and human factors in aviation incidents and accidents.
- Recommendations for aircrew medical criteria, standards, and assessment/certification procedures.
- Quantitative data about the occupational health risks of flight attendants to support regulatory oversight.
- Quantitative data about passenger and aircrew behavior and health to support regulatory oversight.

Customer/Stakeholder Involvement: This program contributes to meeting the FAA Strategic Plan Mission Goal for Safety and ARA FY 2000 Performance Plan Goals for Safety and Human Factors. The program provides the primary bio-aeronautical research (note: defined as the bioengineering, biomedicine, and biochemistry issues associated with safety and performance) called for in the *National Plan for Civil Aviation Human Factors*. This program contributes significantly to the application of emerging technologies, as highlighted in the FAA Aviation Safety Plan. The program is an integral participant and research provider under the FAA, Joint Aviation Authorities (JAA), and Transport Canada Aviation (TCA) Aircraft Cabin Safety Research Plan established in 1995 as a coordinated, living plan to maximize the cost-benefit of aircraft cabin safety research internationally.

International Civil Aviation Organization (ICAO) initiatives addressing the health of the aircraft occupant (crew and passenger) are developed under this program before final FAA recommendations are provided to ICAO. This program is the only research component of the FAA that can legally access confidential medical data about pilots for use in epidemiological research studies approved by FAA's institutional review board for use of human test subjects. Multi-year collaborative studies performed by the FAA and National Institute for Occupational Safety and Health (NIOSH) into flight attendant and passenger symptomatology and diseases are funded by this budget item to satisfy the mandate placed by Congress upon the agencies in the FY 1994 Appropriation Act.

Accomplishments: Based on aeromedical research at the Civil Aeromedical Institute, the FAA issued an advanced notice of proposed rulemaking concerning the usage and design of child restraints on aircraft. The output of this program's research is permitting the FAA and National Highway Traffic Safety Administration to revise the testing requirements in Federal Motor Vehicle Safety Standard 213, which covers the design of child restraints for use in aircraft. Quantitative data were provided regarding various prototypes of aircraft-specific child restraints being developed as commercial products targeted for airlines. Specialized quantitative crashworthiness assessments for aircraft continued, inclusive of side-facing aircraft seats, and included the use of new state-of-the-art anthropomorphic test dummies with enhanced injury assessment capabilities.

Data are continuously provided to the research sponsor on the role of toxicological and clinical factors associated with each aircraft accident and significant incident. Current findings indicate that about one of six pilots fatally injured in a civilian aircraft accident show evidence of using a prescription drug; one of four has taken an over-the-counter drug; one of 25 has ingested significant positive alcohol; and 1 of 20 is using a significant controlled dangerous substance. Long-term aviation forensic and epidemiological research has helped the FAA to identify human factor roles in accident/incident causation. Specialized clinical evaluations were applied to cases associated with aircraft decompression. Probable seizures and other factors indicative of sudden pilot incapacitation were evaluated.

R&D Partnerships: Several of these partnerships (e.g., FAA/JAA/TCA; FAA/NIOSH) have been referenced in the Customer/Stakeholder Involvement and Accomplishments sections above.

In addition, in each of the program area output categories, the FAA maintains direct cooperative research processes with all the manufacturers responsible for the safety products enumerated (seats, restraint systems, oxygen masks, evacuation slides, etc.). FAA investigators also maintain memberships on every Society of Automotive Engineers committee addressing safety research conducted under this program. The agency maintains a liaison with the American Society of Heating, Refrigeration, and Air Conditioning Engineers committee addressing aircraft cabin air quality status and research. Besides the active involvement in the FAA/JAA/TCA process of oversight for safety research, participants in this program are represented on appropriate subgroups of organizations such as the Aerospace Medical Association, the Civil Aviation Medical Association, and the Professional Aeromedical Transport Association. Close liaison with the military is maintained either through direct project collaboration (e.g., eye injury from lasers, crashworthiness) or through the more global participation in the TriServices Aeromedical Research Panel or North Atlantic Treaty Organization aerospace medical advisory groups.

MAJOR ACTIVITIES & ANTICIPATED FY 2000 ACCOMPLISHMENTS

The following program results have been achieved or are expected to be achieved in FY 2000:

- Performed epidemiological assessment of toxicology factors from fatal civilian aviation accidents.
- Developed guidelines for the use of AEDs on commercial aircraft.
- Evaluated autopsy data from fatal aviation accidents to determine protective equipment and design practices.

- Assessed flight attendant reproductive health hazards (Congressionally requested FAA-NIOSH study).
- Developed a rational performance-based standard for crew protective breathing and vision equipment (CPBVE).
- Proposed changes to regulations for operational hazards of laser exposure.

KEY FY 2001 PRODUCTS & MILESTONES

The following program results are being scheduled in FY 2001:

- Conduct epidemiological assessment of toxicology factors from fatal civilian aviation accidents.
- Determine the impact of new antihistamines on pilot performance.
- Develop guidelines to reduce in-flight sudden/subtle incapacitation.
- Evaluate autopsy data from fatal aviation accidents to determine protective equipment and design practices.
- Provide guidelines for aircraft cabin occupant health maintenance.
- Determine optimum wide-body exit distribution and access using new wide body evacuation simulator.
- Develop improved fit and comfort standards for oxygen mask systems.
- Evaluate pilot reported medication usage with actual toxicology findings to determine the accuracy of self reporting.

FY 2001 PROGRAM REQUEST:

The Office of Aviation Medicine encounters complex medical decisions during the initial and follow-up medical assessments of airmen who request special medical issuances (e.g., cardiac conditions, neurological deficits, etc.) to permit their continued flying. The prospective epidemiological assessment of special issuance methodology and medical outcomes in the airman population is required to ensure that medical issuances do not result in unexpected or increased aircraft accident or incident rates or risks.

Ongoing research projects will:

- Develop safer aircraft cabin evacuation approval guidelines and safer field applications under operational conditions.
- Reduce head, neck, and extremity injuries in aircraft crash environments.
- Evaluate trends in toxicology and clinical findings from all major civil aviation aircraft crashes.
- Develop guidelines for aircraft cabin crew and passenger environmental management.

A08c - Aeromedical Research Product and Activities	FY 2001 Request ($000)	Program Schedule					
		FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY2005
086-110 Aeromedical Research							
Cabin Health and Environmental Guidelines							
Assess Flight Attendant Reproductive Health Hazards		◆	◇	◇	◇		
Report on Guidelines for Aircraft Cabin Occupant Health Maintenance		◆	◇	◇	◇	◇	
Develop a Model of Disease Transmission Via Aerosols in an Aircraft Cabin Environment			◇				
Human Protection/Survival in Civil Aviation							
Analyze the Suitability for Component Tests as an Alternative for Showing Regulatory Compliance with Crashworthiness Standard for Aircraft		◆	◇	◇	◇		
Assess Impact Protection Performance of Aircraft Seating Systems, Including Child Restraints		◆	◇	◇	◇	◇	◇
Develop Performance-Based Narrow and Wide Bodied Aircraft Cabin Evacuation Approval Guidelines		◆	◇	◇	◇	◇	◇
Report on Suitability of Aircraft Cabin Evacuation Modeling as a Partial Replacement for Evacuation Tests with Human Subjects		◆	◇	◇	◇		
Evaluate Dual Aisle Evacuation Model						◇	
Develop Improved Oxygen Mask Fit and Comfort Standards		◆	◇				
Analyzed the Influence of Cabin Crew Duty Stations on Evacuation Performance of Passenger Aircraft in Panic Situations		◆					
Survey Parents Flying With Small Children on Their Likelihood to Divert to Other Modalities if Child Restraints are Required			◇				
Develop Standards for Protective Breathing Equipment				◇			
Medical/Toxicology Factors of Accident Investigations							
Perform Epidemiological Assessment of Toxicology Factors from Fatal Civilian Aviation Accidents		◆	◇	◇	◇	◇	◇
Develop Guidelines to Reduce In-flight Sudden/Subtle Incapacitation		◆	◇	◇	◇	◇	◇
Compared Toxicology Findings at Time of Flight Physical to Post-Accident Data		◆					
Evaluate Autopsy Data from Fatal Aviation Accidents to Determine Protective Equipment and Design Practices		◆	◇	◇	◇	◇	◇
Reported on the Impact of the Drug Abatement Program on Aviation Accidents/Incidents		◆					
Develop Toxicological Test to Distinguish Between Ingested and Post-Mortem Alcohol						◇	
Survey of In-flight Medical Emergencies and Defibrillator Usage on Commercial Airline Flights			◇				
Determine Impact of Hypoxia on the Metabolism of Antihistamines			◇				
Personnel and Other Costs	$5,049						
Total Budget Authority	$5,049	$4,829	$5,049	$5,322	$5,610	$5,912	$6,231

Note: Out year numbers are for planning purposes only. Actual funding needs will be determined through the annual budget process.

Budget Authority ($ in Thousands)	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Enacted	FY 2001 Request
Contracts	0	0	313	394	0
Personnel Costs	3,320	3,320	3,155	3,858	3,893
Other Costs	680	680	597	577	1,156
Total	4,000	4,000	4,065	4,829	5,049

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2.6 Environment And Energy Program Area Description

Mission

The 1995 National Science & Technology Council Report, *Goals for a National Partnership in Aeronautics Research and Technology,* predicted that: "Environmental issues are likely to impose the fundamental limitation on air transportation growth in the 21st century." Thus, the scientific assessment and development of safe and affordable options for mitigating the impacts of aircraft noise and emissions are important not only to protect the environment but also to sustain the growth of aviation. In response, the FAA has adopted the following strategies:

- Lead a cooperative development effort that balances noise reduction with adequate airport capacity.
- Manage FAA activities to understand and minimize adverse environmental consequences and comply with all federal statutes.
- Stimulate private industry and government sponsored research to reduce noise, emissions, and energy consumption by the aviation sector.
- Harmonize international aircraft noise and engine emissions certification standards.

Intended Outcomes

Using its regulatory authority, FAA must serve as an advocate for both the environment and industry. Through an optimal mix of aircraft and engine certification standards, operational procedures, compatible land use, and abatement technology, FAA intends to minimize the global, regional, and local impact of aircraft exhaust emissions.

Program Area Outputs

FAA aviation environmental research produces:

- Noise and emissions standards for the certification of new and modified airframe and engine type designs.
- Technical guidance on certification procedures and practices for manufacturers and modifiers in the form of technical reports, handbooks, advisory circulars, training courses, and rules.
- Computer models and impact criteria for civil aviation authorities to use in the environmental assessment of proposed actions.

Program Area Structure

The aviation environmental research program is a single budget line item, Environment and Energy, and composed of the following major disciplines:

- Aircraft noise reduction and control
- Engine emissions reduction and control
- Aviation environmental analysis

These topics form a cohesive system of research projects that support federal actions to identify, control, and mitigate the environmental consequences of aviation activity.

Customer/Stakeholder Involvement

To mitigate potential adverse impacts to the environment, the FAA works closely with other federal agencies, industry, and foreign governments through a unified regulatory-R&D approach to assess environmental concerns, plan R&D, shape technical requirements, identify feasible abatement technologies or other mitigation actions, and implement aircraft and engine certification regulations. The agency utilizes the following arenas to promote collaboration on aviation environmental issues:

- The Aviation Regulatory Advisory Committee (ARAC) — a formal standing committee composed of representatives from aviation associations and industry. Established by the FAA, ARAC provides industry's recommendations, advice, and information applicable to the full range of FAA rulemaking activities. The harmonization working groups under ARAC have been tasked to ensure that certification regulations impacting both domestic and foreign parties do not impose inconsistent standards in participating countries.
- The International Civil Aviation Organization's (ICAO) Committee on Aviation Environmental Protection (CAEP) — a standing committee that establishes and assesses the adequacy of international aviation environmental standards, especially in the areas of aircraft noise and engine exhaust emissions

standards. The FAA participates, as the United States member along with representatives of other civil aviation authorities and observers from aviation industry.

- The Federal Interagency Committee on Aviation Noise (FICAN) — a permanent body that conducts annual public forums in different geographic regions of the nation to solicit general input on aviation noise. FICAN was established by FAA and other federal agencies with ongoing interests in better aligning R&D with the public's concerns.

Accomplishments

In recent years, the program has produced the following:

- Five reports to Congress on the annual progress of the FAA/NASA subsonic jet noise research program.
- A report to Congress on quiet aircraft technology for light propeller-driven airplanes and helicopters that has led to a joint FAA/NASA research project on general aviation noise.
- Advances in the computer models used for airport and heliport noise analysis. Over 1000 copies have been sold around the world. In the U.S., these models have been used in over 150 airport studies involving more than $1.3 billion in airport noise compatibility grants.
- Four public forums on aviation noise research in Atlanta, San Diego, Seattle, and Washington. Public participation has resulted in four FICAN annual reports, one report on federal aviation noise research projects, a report to Congress on the effects of aircraft noise, a federal finding on the relationship between aircraft noise and sleep awakenings, and various new federal research projects on commuter airplane noise impacts and the influence of ambient noise on community annoyance.
- Acceptance at the EPA's highest level ("preferred guideline model") of enhancements to the computer model supporting airport air quality analysis.
- Development of a handbook, for use by civil and military aviation authorities, in which new procedures for airport air quality analysis are defined to improve the quality of federally-reviewed environmental assessments.
- An aircraft overflight noise exposure prediction model for Grand Canyon National Park.
- A new aircraft noise and performance database for use in FAA's Integrated Noise Model (INM).

R&D Partnerships

FAA participates with others in the aviation community in the following joint R&D efforts:

- A series of memorandums of understanding enabling the FAA to work with NASA and U.S. industry to identify source noise and emissions abatement technologies.
- Collaboration with EPA, NASA, industry, and academia to assess the local and global impacts of aircraft engine exhaust emissions.
- Support of the Volpe National Transportation Systems Center's(VNTSC) continuing efforts to provide substantial technical assistance in aircraft noise measurement and assessment.

In addition to the FAA, the U.S. Air Force, the U.S. Army, the U.S. Navy, the Department of Interior, the Department of Transportation, the U.S. Environmental Protection Agency, NASA, and the Department of Housing and Urban Development participate on FICAN, the recognized forum for partnership among all federal agencies concerned with aviation noise. FICAN has led to expanded coordinated and cooperative research efforts among the individual agencies and, thus, results in more efficient use of federal funds. Agencies have signed a letter of understanding formally documenting their participation on the committee and defining its purpose, scope, membership, process, and products.

Long-range View

Planning for environmental research needs beyond 2000 requires a look at key indicators. These are generally described as driving forces for change, targets of opportunities, or future (environmental) threats. Some key indicators that may influence aviation environmental research include:

- Scientific findings
- Air transportation growth

- New aviation technologies
- Increased globalization of aviation
- Reduced federal resources

FAA predicts steady growth of the demand for aviation services into the first decade of the next millennium. The growth in aircraft operations required to meet this demand will result in increased environmental impacts and thus create barriers to further growth.

The key to successful environmental planning is to identify operational mitigation options for those sectors of the growing aviation markets that are most likely to reach environmental critical mass. FAA will need to continue to assess the situation to determine whether research to support mitigation should be directed, for example, towards tour operations over national parks, urban vertiports, resurgent general aviation activity, the old standby large jet transport operations, or a new threat.

Major NASA aeronautics research programs are coming to an end; most notably, the AST program. Several technologies will enter the marketplace within 10-15 years come out of these NASA research programs for use by U.S. industry in the next generations of aircraft. With the end of the AST program, FAA will close its companion research program on subsonic noise reduction. The agency will use its research findings to consider new environmental certification standards and procedures for the next generation of transport aircraft. FAA will shift future environmental research in the field of new aircraft technology toward other research programs and emphasize rotorcraft and general aviation.

The solution to controlling the environmental consequences of new aircraft technologies is through a coordinated regulatory and R&D approach involving the FAA with other federal agencies, such as EPA, NASA and DOD, from the early stages of the technology research.

Technologies, such as the Global Positioning System (GPS), are already beginning to have a profound effect on the aviation system. As these technologies are being introduced to improve system efficiency and flexibility, a new FAA paradigm is emerging under the general term, "Free Flight." As the FAA builds more user flexibility into the NAS, the agency must expand the current suite of environmental analysis tools in all domains to determine the likely environmental impacts and improvements stemming from its support of Free Flight.

While human (animal) behavioral research is generally not the responsibility of the FAA, the agency must devote research resources to apply pertinent scientific findings on environmental impacts into federal guidance and policy. The findings of earlier FAA and NASA scientific studies also have now been incorporated in the Intergovernmental Panel on Climate Change Special Report on Aviation and the Global Atmosphere, requiring consideration of national and international actions to mitigate global climate change.

As stated in FAA's 1998 Strategic Plan, "The globalization of aerospace, U.S. business, and travel is another factor driving change." What is the potential effect of expanding international and multinational manufacturing centers on the harmonization of international aircraft noise and engine emissions certification procedures and recommended practices? FAA must plan research efforts to support continued international harmonization and standardization of the aviation environmental certification standards and procedures.

The prospect of reduced resources has driven FAA to reorganize and streamline to operate more productively and to identify mission-critical services. Historically, environmental research has accounted for only 2% of the R,E&D budget. Funding constraints and further reductions are expected to continue to put a premium on identifying the research projects that are critical to FAA's environmental mission. FAA must continually assess the situation in order to effectively target its diminishing resources. Projects that will best address the agency's prime environmental responsibilities through the promulgation of new or improved aviation environmental standards must be given top priority.

To more effectively channel the diminished research resources, FAA embarked on the *Aviation Environmental Research Beyond 2000* project. Through a series of public meetings and workshops, FAA identified environmental issues and needs that could be addressed through research. The proposed FY 2001 research program ad-

dresses the R&D effort to support an effective environmental mitigation strategy and to identify the best approaches for addressing current environmental concerns.

A09a — Environment and Energy

GOALS:

Intended Outcomes: The FAA intends to: reduce the impact of aircraft noise by 80 percent (based upon the 1992 population exposed to DNL 65dB) and prevent any increase thereafter through an optimal mix of new aircraft certification standards, operational procedures, compatible land use, and abatement technology; define and minimize the impact of aircraft emissions, through an optimal mix of new aircraft certification standards, operational procedures, and abatement technology; and mitigate the environmental consequences of aviation operations.

Agency Outputs: The findings of aviation environmental research have resulted in the publication of significant standards, rules and technical guidance including:

- Standards for the certification of new and modified designs for the reduction of aircraft noise and engine exhaust emissions.
- Technical reports, handbooks, Advisory Circulars (AC), training courses, and procedures for use by manufacturers and modifiers.
- Computer models and impact criteria for use by civil aviation authorities in the environmental assessment of proposed actions.

Customer/Stakeholder Involvement: The FAA uses a unified regulatory R&D approach—working closely with other federal agencies, industry, and foreign governments—to guide R&D efforts into the impact of aviation upon the environment. Lessons learned from this research identify and shape technologies, regulations, and certification criteria that offer potential to improve our present and future global environment.

The Aviation Regulatory Advisory Committee (ARAC) is a formal standing committee, composed of representatives from aviation associations and industry. Established by the FAA, ARAC provides industry input in the form of recommendations, advice, and information to be considered in the full range of FAA rulemaking activities. ARAC's harmonization working groups have been tasked to ensure that the aircraft noise certification regulations that impact both domestic and foreign parties do not impose different standards in each country involved.

The FAA represents the United States on the International Civil Aviation Organization's (ICAO) Committee on Aviation Environmental Protection (CAEP) along with representatives of other civil aviation authorities and observers from the aviation industry. The purpose of CAEP is to establish and assess the adequacy of international aviation environmental standards, especially in the areas of aircraft noise and engine exhaust emissions standards.

The FAA and other interested federal agencies established the Federal Interagency Committee on Aviation Noise (FICAN) to provide forums for debate over needs for future aviation noise research and to encourage new efforts in this area. FICAN conducts annual public forums in different geographic regions to solicit general input on aviation noise impacts with the intent to better align research with the public's concerns.

The Aviation Environmental Research Program directly supports the General Aviation action plan in demonstrating noise abatement technologies for light propeller driven airplanes.

Accomplishments:

- Produced reports to Congress—
  - Report on quiet aircraft technology for light propeller driven airplanes and helicopters. The finding of this report has led to a joint FAA/NASA research project on general aviation noise.
  - Report on the effects of aircraft noise.
  - Five reports on the annual progress of the FAA/NASA subsonic jet noise research program.

Developed advanced computer models—Used for airport and heliport noise analysis. Have resulted in over 1000 copies sold around the world. In the United States, these models have been used in over 160 airport studies involving more than $1.3 billion in airport noise compatibility grants. This program has also produced an aircraft overflight noise exposure prediction model for Grand Canyon National Park.

- Public forums on aviation noise research:

  - Atlanta
  - Minneapolis
  - San Diego
  - Seattle
  - Washington, DC
- Special reports and findings:
  - Four FICAN annual reports.
  - One report on Federal aviation noise research projects.
  - One federal finding on the relationship between aircraft noise and sleep awakenings.

Funding has also led to enhancements to the computer model used for airport air quality analysis and formal acceptance by EPA as a preferred guideline model—EPA's highest ranking—and to the development of a handbook on the procedures for airport air quality analysis for use by civil and military aviation authorities. Standardizing the civilian and military analytical procedures will improve the quality of environmental assessments that are reviewed by the Federal Government.

R&D Partnerships: The FAA works closely with NASA through a series of memorandums of understanding to identify source abatement technologies. The FAA also participates with NASA, industry, and academia to assess the possible global impact of aircraft engine exhaust emissions. The Volpe National Transportation Systems Center (VNTSC) continues to provide substantial technical assistance in the areas of aircraft noise measurement and assessment. FICAN is also a forum for partnership as all Federal agencies concerned with aviation noise are represented on the Committee. FICAN has led to expanded coordinated and cooperative research efforts among the individual agencies and resulted in more efficient use of federal funds.

MAJOR ACTIVITIES AND ANTICIPATED FY 2000 ACCOMPLISHMENTS:

Aircraft noise reduction and control.

- Submitted final report to Congress on the joint FAA/NASA subsonic jet noise reduction technology program.
- Harmonized FAA helicopter noise certification regulations with those of the European Joint Aviation Authorities that govern the procedures used by airframe manufacturers.

Engine emissions reduction and control.

- Updated the FAA Engine Exhaust Emissions Databank to be consistent with the ICAO database.
- Continued to examine alternative, simplified engine exhaust emissions measurement procedures to reduce manufacturers certification test costs.

Aviation environmental analysis.

- Released Integrated Noise Model (INM) Version 6 for use in airport noise assessments.
- Completed the first phase of the validation of the Grand Canyon National Park aircraft overflight noise model.
- Continued to examine and validate methodologies used to assess aircraft noise exposure and impact.

KEY FY 2001 PRODUCTS AND MILESTONES:

Aircraft noise reduction and control.

- Perform flight demonstration of propeller driven light airplane noise reduction technology concepts.
- Publish an update of the noise certification handbook (replacement for AC 36-4).

Engine emissions reduction and control.

- Develop a harmonized, simplified engine exhaust emissions certification test procedure that will increase efficiency and reduce costs of the tests.

Aviation environmental analysis.

- Continue to examine and validate methodologies used to assess aircraft noise exposure and impact.
- Release the new emissions and dispersion modeling system.

FY 2001 PROGRAM REQUEST:

Major NASA aeronautics research programs have come to an end. Several new source technologies will emerge from NASA's research. This will be

the basis, in five to seven years, for the next generation of U.S. industry aircraft. The FAA will close its companion research program on subsonic noise reduction and use its research findings to identify new environmental certification standards and procedures for the next generation of transport aircraft. The FAA will shift future environmental research towards development of new and of improved computer models that will be used to assess aircraft noise, local air quality, and global climate change. In accordance with the National Environmental Policy Act, the FAA must consider and mitigate the environmental consequences of its actions. A variety of methodologies and research are necessary to support and properly assess the environmental impact of aviation. The objective is to enhance and advance computer modeling techniques to better estimate environmental impacts. The FAA will continue to work with NASA, the manufacturing industry, and foreign authorities to provide technical support for development and implementation of aircraft environmental certification regulations through proactive response to changes in airplane technology, measurement/analysis technology, regulatory policy, and international regulatory initiatives.

A09a - Environment and Energy Product and Activities	FY 2001 Request ($000)	Program Schedule					
		FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY2005
091-110 Aircraft Noise Reduction & Control							
Airplane and Rotorcraft Noise Reduction Technologies, Noise Certification Standards & Procedures	$2,327						
Harmonized FAA Noise Certification Regulations with European Joint Aviation Authorities		◆					
Report to Congress on FAA/NASA Subsonic Jet Noise Reduction Research		◆	◇	◇			
Final Assessment of FAA/NASA Light Propeller-Driven Airplane Noise Reduction Technology Research			◇				
Publish Advisory Circular (AC) 36-4d			◇				◇
Complete Rulemaking to Amend Helicopter Certification Requirements in 14 CFR Part 36						◇	
091-111 Engine Emissions Reduction & Control							
Engine Exhaust Emissions Reduction Technologies, Standards and Procedures, and Impact Assessments	$2,200						
Updated the FAA Engine Exhaust Emissions Databank to be Consistent with the ICAO Data Base		◆					◇
Develop a Harmonized, Simplified Engine Exhaust Emissions Certification Test Procedure			◇				
Update Advisory Circular (AC) 34-1							◇
Harmonize FAA Engine Exhaust Emissions Certification Regulations with European Joint Aviation Authorities					◇		
091-113 Aviation Environmental Analysis							
Develop Noise and Air Quality Assessment Methodologies	$1,600						
Released Integrated Noise Model (INM) Version 6 for Use in Airport Noise Assessments		◆					
Completed the First Phase of the Validation of the Grand Canyon National Park Aircraft Overflight Noise Model		◆					
Validate the Methodologies Used to Assess Aircraft Noise Exposure and Impact				◇		◇	
Release INM Version 7							◇
Develop New Helicopter Modeling Methodology and Expanded Helicopter Data Base						◇	
New Emissions and Dispersion Modeling System			◇				◇
Personnel and Other Costs	$1,316						
Total Budget Authority	**$7,443**	**$3,481**	**$7,443**	**$7,564**	**$7,728**	**$7,939**	**$8,198**

Note: Out year numbers are for planning purposes only. Actual funding needs will be determined through the annual budget process.

Budget Authority ($ in Thousands)	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Enacted	FY 2001 Request
Contracts	3,600	2,891	2,239	2,856	6,127
Personnel Costs	0	0	607	589	1,226
Other Costs	0	0	45	36	90
Total	**3,600**	**2,891**	**2,891**	**3,481**	**7,443**

2.7 National Aviation Research Plan Program Management

Mission

The program provides for the effective and responsible stewardship of the funds that users of the NAS have entrusted to the FAA for research and development. We strive to provide our customers the outputs and outcomes they most need in return for their investment.

Intended Outcomes

- This area supports FAA strategic goals and objectives in industry vitality, global leadership, business practices, and communications. Specifically, work in this area is directed towards better serving the interests of the nation and the flying public by:
- Increasing knowledge of the R,E&D program among the agency's customers and stakeholders.
- Increasing the participation of R,E&D customers and stakeholders in the program's formulation.
- Better managing limited R&D resources through more efficient and effective processes for the development and management of the FAA R,E&D investment portfolio.
- Fostering U.S. aviation industry leadership through international cooperation and harmonization in developing and implementing technologies that improve air traffic safety and efficiency.
- Achieving higher quality research and greater value though increased collaboration (partnerships) with the best academic and industrial R&D talent, both within the United States and internationally.
- Vitalizing the U.S. aviation industry by directing its R&D efforts toward the future technological needs of NAS users.

Program Area Outputs

- The (annual) *National Aviation Research Plan (NARP)*, formerly known as the *Federal Aviation Administration Plan for Research, Engineering & Development.*
- Periodic and special R,E&D Advisory Committee reports and recommendations.
- The annual FAA R,E&D Budget.
- International planning and implementation documents providing for world-wide aviation research harmonization and interoperability.
- Agreements with other international civil aviation authorities for the cooperative development of aviation systems research programs.
- Cooperative research agreements with academia, other government agencies, and industry.

Program Area Structure

The NARP Program Management effort is divided into the following areas:

1. Establish an Aging Transport Systems Advisory Committee to coordinate the Plan's initiatives.
2. R,E&D Strategic Management
3. R,E&D Portfolio Analyze
4. R,E&D Financial Management
5. R,E&D Advisory Committee
6. International cooperative research and development programs
7. Collaboration with NASA Field Offices
8. R,E&D Partnerships

Effective stewardship of the FAA R,E&D program requires that all NAS users receive the best systems and services achievable for their investment. In the first four elements just listed, the FAA ensures that its R&D program effectively targets the needs of those who rely on the NAS, that the agency provides for R&D in its budget and R,E&D Plan, and that it properly accounts for its R,E&D financial resources.

The remaining elements provide assurances that FAA is not funding research being duplicated elsewhere, particularly by NASA. FAA-funded researchers must have detailed knowledge of all similar research efforts, here and abroad, in order to be confident that their own work truly complements that of others.

The FAA must leverage its limited research dollars by sharing research resources with industry, academia, and other government agencies. The final program element, "R,E&D Partnerships," is directed toward this goal. Through its extensive network of R,E&D partnerships, the agency affords individual projects a single source of expertise and a consistent service element that helps them enter into cooperative research programs with minimal bureaucratic fuss. This element is described in detail in the "white sheet" for budget line item A10a, "Strategic Partnerships."

Customer/Stakeholder Involvement

The FAA relies upon the R,E&D Advisory Committee (REDAC) for guidance on its research and development programs. The REDAC includes representatives of associations, users, corporations, other government agencies, universities and research laboratories—all either customers or stakeholders of FAA products and services. The REDAC is actively involved in shaping, reviewing, and questioning what the agency is presently doing or considering for the future.

Accomplishments

NARP Strategic/Financial Management and Portfolio Analysis.

- The 1999 FAA *National Aviation Research Plan*, March 1999.
- The FY 2000 R,E&D Budget, January 1999.
- R,E&D Portfolio Development Process Reengineering - Update, July-September, 1999.

R,E&D Advisory Committee.
(See Appendix A.)

R,E&D Coordinated Efforts and Partnerships.

Industry Research Programs Group:

- *Technology* Transfer:
- Negotiation/Award of Cooperative Research and Development Agreements
  - Negotiation of Patent Licenses.
  - Technical Assistance to state and local governments, and other federal agencies.
  - Technical Assistance to private industry to develop commercial products for the aviation market.
  - Participation at technology conferences and expositions to inform potential new partners of the needs and capabilities of the FAA.
- Small Business Innovation Research:
  - Design and installation, by Delta Systems, of an FAA compressed video telecommunications network for ATM RADARS.
  - Commercial production of a compact neutron source, by Accsys Technology, for explosives detection.
- Cooperative Research and Development Agreements:
  - Completion of a cooperative research and development agreement (CRDA) with the U.S. Air Force's Wright Laboratory—their premier aeronautics laboratory—for joint research in advanced flight control systems and improved reliability for aircraft engines, October 1996.
  - Completion of a CRDA with the U.S. Air Force's Rome Laboratory—their premier C3I laboratory—for joint research in advanced air-to-ground communications and communication architecture research, August 1996.
  - Negotiation of a CRDA with Boeing to build the National Airport Pavement Test Machine.

University Research Program Group:

- Aviation Research Grants:
  - Award of a CRDA in FY97 to the Experimental Aircraft Association Foundation for joint research in satellite-based communications, navigation, surveillance, and air traffic control/management systems for the general aviation environment.
  - Award of a CRDA in FY97 to L-3 Communications, to design, fabricate, and test a next generation high speed computed

tomography system for explosives detection.

- Negotiation, in FY97, of a total of $10,000,000 in savings to the Government via cost sharing in awarded grants and CRDAs.

- Centers of Excellence:
  - Establishment, in FY-97, of a Center of Excellence in Airworthiness Assurance (COE-AWA) under the leadership of Iowa State and Ohio State Universities.

- Joint University Program:
  - Presentation of 15 RTCA Jackson Awards for excellence in aviation electronics.
  - Presentation of the first FAA Excellence in Aviation Award, two AIAA Major Field Awards in aviation meteorology, and one IEEE Major Field Award in control systems.
- University Fellowship Program:
  - FAA Executive Steering Committee approval for a special training and development program to allow agency employees to become FAA Fellows.

R&D Partnerships

- Established partnership with Federal Quality Consulting Group on process reengineering.
- Received and incorporated the R,E&D Advisory Committee's guidance on the R,E&D Program.
- Established 125 research and development agreements with 19 countries and with a single air traffic organization representing 17 member states.
- Established an agreement with Eurocontrol to do cooperative research and development in air traffic management programs.

Long-Range View

Work in this area will continue as long as the FAA performs research and development. Expected resource requirements in the out-years will remain at about 3-5% of the total R,E&D budget.

A01a —System Planning and Resource Management

GOALS:

Intended Outcomes: The FAA intends that its R,E&D programs more effectively meet customer needs, increase program efficiency, and reduce management and operating costs. The FAA further intends to increase customer and stakeholder involvement in its programs by fostering greater proliferation of U.S. standards and technology to meet worldwide aviation needs.

Agency Outputs: The FAA prepares the annual R,E&D budget submission to Congress and publishes the annual *National Aviation Research Plan (NARP).* The agency hosts three R,E&D Advisory Committee (REDAC) meetings per year as well as a number of subcommittee meetings. REDAC produces periodic and special reports providing advice and recommendations on the R,E&D program to the FAA.

Customer/Stakeholder Involvement: REDAC reviews the FAA's research commitments annually and provides guidance for future R,E&D investments. The Advisory Committee is limited to a maximum of 30 members. These members represent customer and stakeholder groups as well as subject matter experts from various associations, user groups, corporations, government agencies, as well as universities and research centers.

Accomplishments: Each year, the agency provides R,E&D program status information through the *National Aviation Research Plan* and submits the R,E&D budget requests to the Office of Management and Budget (OMB) and Congress. REDAC has provided the FAA with an independent strategic view on the agency's research commitments. In recent reports, the committee has reviewed the Air Traffic Services program area (March 1999) and the FAA's planned FY 2001 R,E&D Investments (April 1999). The Committee has also participated in a joint meeting with NASA's Aero-Space Technology Advisory Committee (January 1999).

R&D Partnerships: The FAA's R&D partnerships are described in each budget line item.

MAJOR ACTIVITIES AND ANTICIPATED FY 2000 ACCOMPLISHMENTS:

R,E&D plans and programs.

- Published the National Aviation Research Plan.
- R,E&D advisory committee.
- Submitted Committee review of and recommendations for FY 2002 R,E&D Program.
- Submitted Committee guidance for FY 2003 R,E&D Program.
- Participated in joint meetings with NASA's Aero-Space Technology Advisory Committee.

International.

- Worked with technical panels of the International Civil Aviation Organization (ICAO) [examples: the Automatic Dependant Surveillance Panel (ADSP), the Aeronautical Telecommunications Network Panel (AMCP), the Global Navigation Satellite System Panel (GNSSP) and the Review of the General Concept of Separation Panel (RGCSP)], and Offices within the Office of Research and Acquisitions (ARA) on the design and submission for approval of new Standards and Recommended Practices (SARPS).
- Worked with the Planning and Implementation Regional Groups (PIRGs) of ICAO to ensure that technologies and operational plans being implemented support the concept of a seamless global navigation system.
- Supported ASD-500 in its primary responsibility for ensuring that the international activities cited in this section are managed and coordinated within ARA to ensure the protection and defense of the interests of the United States.
- Supported additional ASD-500 responsibilities, including: (1) the Secretary of Transportation's designated chair of the Satellite Navigation and Communication (SV&C) Advisory Group of the Transportation Working Group (TPT-WG) of the Asia Pacific Economic Cooperation (APEC), and (2) the des-

ignated ARA Clearance Office for all international aviation policy issues coordinated through the Interagency Group on International Aviation (IGIA).

KEY FY 2001PRODUCTS AND MILESTONES:

R,E&D plans and programs.

- Publish the National Aviation Research Plan.
- R,E&D advisory committee.
- Prepare Air Traffic Services Report.
- Prepare Airport Technology Report.
- Prepare Environment and Energy Report.
- Prepare recommendations on planned R,E&D investments for FY 2003.
- Prepare other reports as requested by the Administrator.
- Participate in joint meetings with NASA's Aero-Space Technology Advisory Committee.

International.

- Ensure global compliance with the Y2K issue.
- Obtain global acceptance of World Geodetic Standard-84 (WGS-84).
- Establish initial GPS for global enroute navigation.

FY 2001 PROGRAM REQUEST:

The FAA's R,E&D program strategic management encompasses four distinct steps to plan the program, and four steps to execute the plan. These steps differ markedly from project level tactical planning and execution. They neither replace nor duplicate those efforts. These steps provide a structured program portfolio that unifies customer needs with limited available resources.

Step one, the planning phase, identifies specific FAA outputs to achieve desired outcomes. This step must include customer and REDAC participation to accurately identify the research needed to meet product and service requirements.

Step two groups product and service requirements into six major service areas. Teams assigned to each of these areas study the requirements and devise an overall, integrated approach to satisfy it. The service areas provide a mechanism that groups similar requirements so that those related to a specific area, such as air traffic services, are considered together.

Step three develops a set of research projects to support the strategy; it also provides the necessary R&D products for the needed outputs once the service area establishes the integrated strategy in step two. To achieve desired outcomes in this step, the R,E&D Advisory Committee must provide input on the quality and potential of proposed research projects.

Step four establishes a cross-functional management team to review the work of the individual service area teams and to balance the work across the areas. This ensures the most important work is accomplished with the available resources. During this final step, the REDAC conducts a review of the proposed program and provides recommendations to FAA decision makers. The R,E&D investment portfolio should result and form the basis for the FAA's R,E&D budget submission to Congress.

The execution phase provides core, essential services across all the service areas. It produces the following:

- Financial management of the R,E&D program.
- Financial support for REDAC, a body of customers and aviation experts drawn from outside the FAA who provide guidance to the Administrator on R,E&D program planning and execution.
- Negotiation and execution of bilateral and multilateral agreements with international civil aviation authorities. These agreements establish cooperative R,E&D programs, system standards, and air traffic system procedures.

A01a - System Planning and Resource Management Product and Activities	FY 2001 Request ($000)	Program Schedule					
		FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY2005
011-130 R,E&D Plans and Programs							
R,E&D Plans and Programs	$854						
Publish Annual Plan for R&D		◆	◇	◇	◇	◇	◇
R,E&D Financial Management		◆	◇	◇	◇	◇	◇
Prepare Annual Budget Submissions		◆	◇	◇	◇	◇	◇
R,E&D Advisory Committee Reports	$220						
Recommendations on FAA, RE&D Investments		◆	◇	◇	◇	◇	◇
Joint Meetings with NASA's Aerospace Technology Advisory Committee		◆	◇	◇	◇	◇	◇
Personnel and Other Costs	$276						
Total Budget Authority	$1,350	$1,164	$1,350	$1,374	$1,405	$1,444	$1,493

Note: Out year numbers are for planning purposes only. Actual funding needs will be determined through the annual budget process.

Budget Authority ($ in Thousands)	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Enacted	FY 2001 Request
Contracts	200	1,164	385	1,164	1,074
Personnel Costs	1,378	0	685	0	246
Other Costs	282	0	94	0	30
Total	1,860	1,164	1,164	1,164	1,350

A01b —William J. Hughes Technical Center Laboratory Facility

GOALS:

Intended Outcomes: The FAA test beds located at the William J. Hughes Technical Center (WJHTC) support R,E&D program goals to:

- Reduce the number of accidents and accident risk.
- Perform airspace studies and improve airspace design.
- Increase airport capacity.
- Reduce delays due to weather and system outages.
- Reduce unnecessary flight restrictions.
- Reduce user costs.

The WJHTC maintains and operates the agency test bed laboratories utilized by R,E&D programs in achieving the above goals. These centralized test beds consist of non-operational NAS systems, aircraft, simulation facilities, communication systems, and a Human Factors Laboratory.

Agency Outputs: FAA programs develop the technical characteristics for new systems and procedures. R,E&D programs require their test beds to emulate and evaluate various field condition requirements. Human factors projects require laboratories to perform human-in-the-loop simulations, measure human performance, and evaluate human factors issues. Airborne and navigation projects require "flying laboratories" that are specially instrumented and reconfigurable to support different projects. Developmental programs require simulation systems to recreate realistic scenarios.

Customer/Stakeholder Involvement: The test beds directly support agency projects and integrated product teams in the following areas:

- Capacity and air traffic management technology.
- Communications, navigation, and surveillance.
- Operation concept validation.
- Free flight phase 1.
- Weather.
- Airport technology.
- Aircraft safety technology.
- System security technology.
- Human factors.
- Safe Flight 21.
- Environment and energy.
- Traffic alert and improved collision avoidance systems.
- Global Positioning System (GPS).
- Terminal Instrumentation Procedures (TERPs).
- Wide/Local Area Augmentation System (WAAS/LAAS).

Accomplishments: The technical laboratory facilities provide the test bed infrastructure to support R,E&D program goals and outputs.

R&D Partnerships: In addition to the R,E&D programs listed, WJHTC laboratories cooperate with the Canadian Ministry of Transport, NASA, U.S. Air Force, Aircraft Owners and Pilots Association, Experimental Aircraft Association, International Civil Aviation Association, and academia.

MAJOR ACTIVITIES AND ANTICIPATED FY 2000 ACCOMPLISHMENTS:

The following programs have been supported by the laboratories:

- GPS/WAAS/LAAS
- TERPs
- Satellite communication
- Data link
- TCAS/ADS-B
- Separation Standards
- Automated Radar Terminal System (ARTS) IIIE
- Host Replacement
- Y2K End-to-End Testing
- Runway Pavement Testing
- Aircraft deicing
- Aircraft security

- Traffic Flow Management laboratory

KEY FY 2001 PRODUCTS AND MILESTONES:

The test beds at the WJH Technical Center provide the necessary infrastructure for R,E&D programs to achieve their goals. Specific milestones and products are contained within individual programs.

FY 2001 PROGRAM REQUEST:

The WJHTC will maintain and operate technical laboratories/facilities that support R,E&D programs.

A01b - William J. Hughes Technical Center Laboratory Facility Product and Activities	FY 2001 Request ($000)	Program Schedule					
		FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY2005
011-140 WJHTC Laboratory Facility							
Systems Support Laboratory (En Route, Terminal, Automated Flight Station, Communications, and Scan Radars)	$500						
Free Flight Phase 1		◆	◇	◇			
Operational Concept Validation		◆	◇	◇	◇	◇	◇
Capacity Initiatives (Airspace, Procedures)		◆	◇	◇	◇	◇	◇
Research & Development Laboratory (Target Generator Facility, Cockpit Simulator, Auto Tracking, Tech Center Data)	$468						
Approach Procedures (SOIA)		◆	◇	◇	◇	◇	◇
Free Flight Phase 1		◆	◇	◇			
Separation Standards		◆	◇	◇	◇	◇	◇
Operational Concept Validation		◆	◇	◇	◇	◇	◇
GPS/WAAS/LAAS		◆	◇	◇	◇	◇	◇
CDT/ADS-B		◆	◇	◇	◇	◇	◇
Data Link		◆	◇	◇	◇	◇	◇
STARS		◆	◇	◇	◇	◇	◇
Aviation Support Laboratory (Aircraft)	$2,500						
Satellite Communications and Navigation Programs		◆	◇	◇	◇	◇	◇
Separation Standards		◆	◇	◇	◇	◇	◇
Safe Flight 21		◆	◇	◇	◇	◇	◇
GPS/WAAS/LAAS		◆	◇	◇	◇	◇	◇
TERPS		◆	◇	◇	◇	◇	◇
Data Link		◆	◇	◇	◇	◇	◇
TCAS		◆	◇	◇	◇	◇	◇
ADS-B		◆	◇	◇	◇	◇	◇
Aircraft Safety		◆	◇	◇	◇	◇	◇
Human Factors Laboratory	$450						
Air Traffic Control Human Factors		◆	◇	◇	◇	◇	◇
Airway Facilities Human Factors		◆	◇	◇	◇	◇	◇
Operational Concept Validation		◆	◇	◇	◇	◇	◇
Personnel and Other Costs	$9,513						
Total Budget Authority	**$13,431**	**$11,075**	**$13,431**	**$13,977**	**$14,575**	**$15,230**	**$15,944**

Note: Out year numbers are for planning purposes only. Actual funding needs will be determined through the annual budget process.

Budget Authority ($ in Thousands)	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Enacted	FY 2001 Request
Contracts	3,435	3,341	3,268	3,300	3,918
Personnel Costs	2,627	3,905	6.462	6,988	8,044
Other Costs	538	800	0	787	1,469
Total	6,600	8,046	9,730	11,075	13,431

A01c — Center for Advanced Aviation System Development (CAASD)

GOALS:

Intended Outcomes: The FAA intends to apply expertise from the Center for Advanced Aviation System Development (CAASD) resources to air traffic service research to produce a safer, more efficient global air transportation system. Because it augments the agency's inhouse resources in conducting research for the Air Traffic Services (ATS) line of business, CAASD is an essential component of the FAA's research program.

Agency Outputs: The CAASD research program provides detailed reports, briefings, and concept demonstration systems for use in the evaluation of new Air Traffic Management (ATM) and control operating concepts and/or infrastructure replacements. These products are critical elements in the initial development of a more efficient, more available, and safer next generation ATM and control system.

CAASD provides new technology research for applications for global air traffic management, including new developments in traffic flow management, navigation, separation assurance, surveillance technology, and system safety.

Customer/Stakeholder Involvement: The FAA is challenged to increase safety in the nation's civil aviation system while increasing capacity and efficiency. Outcomes within CAASD's work program span system stakeholder as well as FAA issues and needs. Collaborative traffic flow management is included among these important issues and needs.

The CAASD R,E&D effort supports the RTCA Free Flight Steering Committee. This committee provides the principal collaborative forum among industry, aircraft operators, and FAA representatives in developing plans and requirements for the NAS to evolve to free flight. It defines operational needs leading to free flight and identifies the required affordable NAS Architecture that satisfies those needs.

Additionally, the CAASD R,E&D effort supports International Civil Aviation Organization (ICAO) in its efforts to develop worldwide navigation capabilities, including: (1) a wide-area augmentation system; (2) a local-area augmentation system; and (3) a worldwide air-ground communication capability using very high frequency air-ground digital radio. ICAO is the principal venue for international standards development and validation.

Accomplishments: CAASD supported the following accomplishments:

- Assisted in defining a longer term evolution of decision support capabilities to move the ATM system closer to free flight objectives.
- Supported surveillance server prototyping, development, and implementation; and refined the architecture, transition plan, and decommissioning strategies based on test results.
- Investigated procedures, user needs, system requirements, and architecture implications for enhanced information systems.
- Assisted in developing an investment strategy to ensure high-level design decisions based on an integrated evolutionary operational concept.
- Continued to provide the FAA with a strategic understanding of the role technology in developing the future ATM system.

R&D Partnerships: In accomplishing outcomes in the CAASD work program, extensive partnerships have been forged with industry suppliers, aircraft operators, operational FAA facilities, and other nonprofit research institutions. For example, CAASD maintains a cooperative research relationship with ATN Systems, Inc. in order to refine and validate the technical characteristics of an aeronautical telecommunications network router in a timely cost effective manner.

CAASD maintains a cooperative research relationship with the Florida Institute of Technology (FIT) to develop and validate the technical characteristics of flight information services broadcasts in a timely cost-effective manner. As a joint project with FIT, CAASD developed an air ground prototype to disseminate weather information to NAS users in flight.

MAJOR ACTIVITIES AND ANTICIPATED FY 2000 ACCOMPLISHMENTS:

- Developed a greater understanding of the potential of free flight concepts to alter technology and processes for system operations, thus providing more flexible and efficient services.
- Continued investigating procedures, user needs, system requirements, and architecture implications for enhanced information systems.
- Made best use of Global Positioning System (GPS) and advanced avionics technology to reduce operating costs to NAS users.

KEY FY 2001 PRODUCTS AND MILESTONES:

- Research new ATM and control operating concepts evaluation and/or infrastructure replacements.
- Continue to develop a greater understanding of free flight concepts and operating procedures, needed to fully implement associated programs.
- Continue to refine the architecture and transition plan, as well as strategies for planned FAA and user investment decisionmaking tools.

FY 2001 PROGRAM REQUEST:

Funding is requested for the following items:

- Development of free flight enhancements.
- Investigation of the expanded use of GPS and advanced navigation systems.
- Integration of decision support system requirements with FAA and industry technology applications.

A01c - Center for Advanced Aviation System Development (CAASD) Product and Activities	FY 2001 Request ($000)	Program Schedule					
		FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY2005
011-160 Center for Advanced Aviation System Development							
Navigation and Surveillance	$1,500						
Developed Navigation Architecture for Timely and Cost Effective Transition to Satellite-Based Navigation Systems		◆					
Assessed Future Surveillance Alternatives Using Automatic ADS-B Capabilities		◆					
Researched Low Cost Avionics Benefiting Free Flight Paradigm		◆					
Define Relationships Among Safety, Separation Standards, & Operational Capability to Enhance Safety Management		◆	◇	◇	◇	◇	◇
Investigate the Expanded Use of GPS and Advanced Navigation Systems		◆	◇	◇			
Traffic Flow Management (TFM)	$3,500						
Identified Enhancements to Current TFM System		◆					
Developed System Architecture for Implementation of Data Link Infrastructure		◆					
Develop/Integrate FAA Decision Support Systems (DSS) with FAA and Industry		◆	◇	◇	◇	◇	◇
Develop Alternative Methods for Using GPS Technology Inclusion of Free Flight Concepts in Domestic Airspace		◆	◇	◇	◇	◇	◇
Incorporate GPS Technology into Ongoing Work in Area of Low Cost Avionics to Make Full Use of Traffic Alert and Collision Avoidance System (TCAS)		◆	◇	◇	◇		
Continue Investigating Procedures, User Needs, System Requirements, and Architecture Implications for Enhanced Information Systems		◆	◇	◇			
Develop a Greater Understanding of Free Flight Concepts to Potentially Alter Technology and Processes for System Operations		◆	◇	◇	◇	◇	◇
Research New Air Traffic Management and Control Operating Concepts Evaluation and/or Infrastructure Replacements		◆	◇	◇	◇	◇	◇
Develop Free Flight Enhancements		◆	◇	◇	◇	◇	◇
Integrate DSS Requirements with FAA and Industry Technology Applications		◆	◇	◇			
Personnel and Other Costs	$0						
Total Budget Authority	$5,000	$4,900	$5,000	$5,041	$5,114	$5,220	$5,365

Note: Out year numbers are for planning purposes only. Actual funding needs will be determined through the annual budget process.

Budget Authority ($ in Thousands)	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Enacted	FY 2001 Request
Contracts	5,200	5,444	4,890	4,900	5,000
Personnel Costs	0	0	0	0	0
Other Costs	0	0	0	0	0
Total	5,200	5,440	4,890	4,900	5,000

A01d —Information Systems Security

GOALS: Presidential Decision Directive (PDD-63) calls for a national-level effort to protect the increasingly vulnerable and interconnected U.S. computer and communications infrastructure. Executive Order 13010 identifies aviation transportation among the key protection areas. This budget submission focuses on extraordinarily difficult and challenging technical problems that must be addressed as a part of protecting the FAA's system infrastructure.

Intended Outcomes: The FAA will improve information systems security by developing and evaluating technologies, technical information, and procedures that can be applied in many of its information systems, both new and legacy.

Agency Outputs: The research will transition into both future and legacy information systems used for all aspects of agency business, including the NAS, mission support, and administrative. Those systems will be more secure as a result of applying the new technology, improving the safety of the flying public, better protecting the nation's critical infrastructure, and enabling uninterrupted operations of the FAA.

Customer/Stakeholder Involvement:

- Internal stakeholders include all agency personnel since everyone routinely uses information systems for their business. Of special note are controllers (system availability and integrity), maintenance personnel (response to intrusions including system recovery), Aviation Security (incident analysis and enforcement), Regulation and Certification, Research and Acquisition, and the FAA Chief Information Officer (security system oversight).
- Federal stakeholders such as the President's Commission on Critical Infrastructure Protection, the Gore Commission, and the General Accounting Office have raised concerns about protecting the NAS information infrastructure in formal reports.
- External stakeholders include airlines and passengers (safety, efficiency, equipage, and maintenance); aircraft operators (safety, efficiency, equipage, and maintenance); pilots (safety); and International Civil Aviation Organization (standards and recommended practices).

Accomplishments: This is a new research and development program.

R&D Partnerships: Intended partners include Lincoln Laboratory, Massachusetts Institute of Technology, National Security Agency, Department of Defense, Department of Treasury, and NASA.

MAJOR ACTIVITIES AND ANTICIPATED FY 2000 ACCOMPLISHMENTS:

This is a new program.

FY 2001 PROGRAM REQUEST:

For each task under this program, the work will produce advanced information systems security technology and provide a proof-of-concept demonstration that will allow evaluation of that technology. For example, new real-time intrusion detection technology would be evaluated in the FAA's Computer Security Intrusion Response Capability facility, which is the agency's official program to monitor its information systems for attempted intrusions. New public key infrastructure technology would be evaluated in at least one FAA program for which traditional mechanisms require improvement to achieve efficiencies or security.

The research and development will focus on:

- Real Time Intrusion Detection and Monitoring—Significant engineering shortfalls complicate the building and deployment of Intrusion Detection (ID) systems for large, heterogeneous systems such as the National Airspace System (NAS). Current ID systems are not tailored to the security requirements of NAS operational systems. Current technology results in high false alarms and missed detection of actual intruders. The volume of audit data also requires a large personnel staff to analyze the reports. Integrating security data from the very large number of separate NAS subsystems will provide an unparalleled technical challenge. A research and development program is needed to develop intrusion detection technology tailored to FAA requirements and to integrate and tailor state of the

art commercial intrusion detection technology into FAA information systems.

- Architecture—FAA's information infrastructure is one of the largest and most complex in the world. Current techniques to architect the security of information systems need to be significantly improved to ensure that the points of greatest vulnerability have the greatest protection and so that those protections remain as the information systems evolve. A research and development program is needed to develop new architectural approaches and to integrate state of the art architectural approaches into the FAA's information systems security architecture.
- Defensive intelligent agents called BOTS (derived from robots) — Increasingly, intruders use hostile BOTS to seed systems with clandestine agents. Research of hostile BOTS can lead to monitoring tools and development of defensive, intelligent agents. These methods and agents, used with intrusion detection systems, will improve intrusion detection and reduce false alarms. A research and development program is needed to analyze existing BOTS technology, and develop and test the effectiveness of intelligent agents in improving intrusion detection.
- Public Key Infrastructure— The FAA will improve information systems security by researching and developing technologies, technical information, and procedures for public key infrastructure. Such improvements will enable secure transactions over the internet, intranet, and in non-TCP/IP based networks such as those used in air to ground communications via the Controller Pilot Data Link Communications program.

A01d - Information System Security Product and Activities	FY 2001 Request ($000)	Program Schedule					
		FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY2005
011-170 Information Systems Security							
Real Time Intrusion Detection and Monitoring	$1,500						
Develop and Tailor Intrusion Detection Algorithms to the NAS and Other FAA System Requirements				◇			
Build and Test a New Proof of Concept Intrusion Detection System				◇			
Develop and Test Effectiveness of Intelligent Agents in Improving Intrusion Detection				◇			
Identify Countermeasures				◇			
Architecture	$1,500						
Techniques to Improve Effectiveness Against Unauthorized Access				◇			
Integrate State of the Art Architectural Approaches in the Information Systems Security (ISS) Architecture				◇			
Integrate ISS into the FAA Architecture				◇			
Defensive Intelligent Agents Called BOTS (Derived from Robots)	$1,000						
Development of Monitoring Tools				◇			
Development of Defensive, Intelligent Agents				◇			
Integrate with Intrusion Detection				◇			
Analyze Existing BOTS Technology				◇			
Public Key Infrastructure	$1,500						
Research and Develop Technologies, Technical Information and Procedures for PKI				◇			
Integrate and Test Developed PKI Technology into the FAA Architecture for Secure Transactions Over the Internet, Intranet, and in Non-TCP/IP Based Networks Such As Used in Air to Ground Communications via the Controller-Pilot Data Link Communications (CPDLC) Program				◇			
Personnel and Other Costs	$0						
Total Budget Authority	$5,500	$0	$5,500	$5,545	$5,625	$5,743	$5,901

Note: Out year numbers are for planning purposes only. Actual funding needs will be determined through the annual budget process.

Budget Authority ($ in Thousands)	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Enacted	FY 2000 Enacted	FY 2001 Request
Contracts	0	0	0	0	5,500
Personnel Costs	0	0	0	0	0
Other Costs	0	0	0	0	0
Total	0	0	0	0	5,500

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APPENDIX A

RESEARCH, ENGINEERING AND DEVELOPMENT ADVISORY COMMITTEE

The FAA values the ongoing involvement of the R,E&D Advisory Committee in reviewing its current and planned R,E&D programs. A formal process has been established whereby the agency replies to the Committee's reports. This document summarizes recent Committee recommendations and FAA responses.

Since preparation of the *1999 FAA National Aviation Research Plan*, the Committee submitted the following reports:

- *Report of the Subcommittee on Runway Incursion,* dated January 29, 1998 (FAA responses received and incorporated).
- *Committee Guidance for FAA's Planned Fiscal Years 2001-2005Research and Development Investments,* dated November 18, 1998 (FAA responses received and incorporated).
- *Committee Recommendations from the Air Traffic Services Subcommittee,* dated March 5, 1999 (FAA responses received and incorporated).
- *Committee's Recommendations on Fiscal Year 2001-2005 R,E&D Investment Portfolio* (FAA responses pending).

In 2000, FAA expects to receive the Committee's recommendations on FAA's planned research and development investments for fiscal year 2002, including detailed recommendations from the standing subcommittees.

Response to the Report of the Subcommittee on Runway Incursion (Report dated January 29, 1998)

STATUS OF RESEARCH, ENGINEERING, AND DEVELOPMENT ADVISORY SUBCOMMITTEE RECOMMENDATIONS

Recommendation 1. The Federal Aviation Administration (FAA) should expeditiously amend Federal Aviation Regulation 91.129(1) to require a specific air traffic control clearance to cross any runway: MITRE is studying the impact of this change. Action plan reference: 1Bb. Tasks and target dates are as follows:

- Build baseline airport model. Completed on March 29, 1999.
- Document and deliver modeling results. Completed on May 3, 1999.
- Site selection and coordination for field trial. Ongoing.
- Evaluation of field trial. Completion to be determined (TBD).
- Deliver final report. Completion TBD.

Recommendation 2. The FAA should provide directions to airport operators regarding expanding the size, number, and conspicuity of runway holding positions markings.
Action plan reference: 4B.

- Revision to Advisory Circular (AC) 5340-1H. Completed on March 15, 1999.
- Publication of Revision. Completed, September 30, 1999.

Recommendation 3. The FAA should encourage use of runway entrance lighting. Action plan reference: 4B.

Completed with publication of AC's 150/5340-28 and 5345-46B on September 1, 1998.

Recommendation 4. The FAA should develop a standard procedure for use of aircraft lights during surface operations. Action plan reference: 2Ea.

- Review Society of Automotive Engineers (SAE) Committee A-20, with a view toward drafting and presenting a proposed rule project record for aircraft lighting conspicuity, for inclusion in the fiscal year (FY) 2000

agenda for the Regulation and Certification (AVR) Safety Target Area Team. Completed on February 15, 1999.

- Report sent to the SAE Committee on evaluation of runway occupied lighting and lighting/painting schemes. Completed on April 15, 1999.
- Develop standard procedure for use of aircraft lights during surface operations. Completed on July 15, 1999.
- Procedural update forwarded and will be included in the January 2000 change to the Aeronautical Information Manual.

Recommendation 5. The FAA should research ways to improve aircraft conspicuity, particularly to make aircraft more visible from the rear.

- Flight Standards has included guidance in the Aeronautical Information Manual providing suggestions to improve aircraft conspicuity, e.g., turn on lights when operationally practical. In addition, Flight Standards presented the REDAC's request for Conspicuity Research to the RE&D Aircraft Safety TAT on October 20, 1999. The Safety TAT believes the FAA may have already completed research in this area. Flight Standards will forward any such available research to the REDAC within the next 30 working days. After the REDAC has reviewed the existing literature, Flight Standards will entertain any further REDAC requests for additional Conspicuity research.

Recommendation 6. The FAA, in conjunction with industry, should develop specific training for all general aviation pilots to address techniques for surface error prevention. Action plan reference: 2Ba

- Seminar-in-a-Box, a joint Aircraft Owners and Pilots Association, Runway Safety Program, ATO-102, and Aviation Safety Program effort. Items include safety advisors, a 26-minute video, and a Discussion Leader's Guide. Seminars have been conducted by AFS safety personnel for the general aviation pilot community. Completed on April 1, 1999.
- ATO-102 provided each region with runway incursion information for the Flight Standards District Office (FSDO) safety program manager quarterly safety meetings. Completed on August 18, 1999

Recommendation 7. The FAA should provide direction to the airline industry to develop standardized cockpit procedures for surface movement to minimize runway incursions.

- This recommendation was completed on September 3, 1999, with the issuance of a Flight Standards policy letter.

Recommendation 8. The FAA should expand the use of Runway Incursion Action Teams (RIAT). Action plan reference: 4Cb.

- FY 1998 - 7 RIAT meetings accomplished.
- FY 1999 - 20 RIAT meetings accomplished. Twenty scheduled for FY 2000.
- Runway Safety Program order published. Detailed guidance for RIAT makeup and the evaluation process. Completed in August 1999.

Recommendation 9. The FAA should develop an objective method for determining when airport surface markings need repainting. Action plan reference: 4Ac.

Project included in FY 2000 Research and Development Plan submitted to Congress. Completion September 30, 2000.

Recommendation 10. The FAA should continue research on low-cost airport surface detection equipment (ASDE), other ground surveillance, and in-cockpit technologies geared to short-term implementation. Action plan references: 2D, 3Bc, 3C, 4Aa.

- X-Band Surface Detection Radar at the Milwaukee International Airport (MKE) - The

MKE air traffic controllers, as part of an extended operational demonstration, are currently using the Raytheon pulse X- band radar at MKE. The Raytheon ASDE system has been able to track targets in low-visibility conditions and inclement weather. The FAA is in the process of executing an agreement with Raytheon to extend the period of this demonstration for up to 3 additional years.

- LOOP Technology - The FAA is considering extending the testing of the Long Beach inductive LOOP system during FY 2000.
- Phased Array Radar at the Norfolk International Airport - The formal evaluation of the Norfolk phased array ASDE radar was completed in February 1999. The evaluation was delayed due to technical problems experienced during the system test. Most of the problems were corrected and the system has been operating as part of an informal air traffic controller evaluation since February 1999. The completion date for this informal evaluation has not been determined.
- DFW is in the process of testing a multi-lateration surface sensor system that fuses data from other sensor subsystems (i.e., ASDE-3, LOOP, and ADS-B) to provide seamless airport surface coverage. Integration of all system components and data collection has commenced, November 1999. The final demonstration will be in January 2000.

Recommendation 11. The FAA should provide immunity/remedial training for gathering safety data. Action plan references: 1Cf, 1Db, 1Dc.

- A memorandum from AFS-1 to all Flight Standards division managers was issued September 20, 1999.
- Mandatory refresher training for air traffic controllers developed and sent to the field. Completed on April 1, 1999.
- Runway incursion computer-based instruction (CBI) course for air traffic controllers. Completed on March 31, 1999.
- CBI distribution to the field. Completed on October 30, 1999.
- Remedial training for air traffic controllers involved in surface incidents already exists in FAA Order 3120.4, Air Traffic Technical Training.
- Airport operator remedial training program for drivers involved in surface incidents will be accomplished via Cert Alert. Completed
- September 30, 1999.

Recommendation 12. The FAA should study runway exiting to determine ways pilots can ensure that the aircraft tail is clear of the runway. Action plan reference: 4Ab.

An analysis indicated there was no significant trend attributable to this occurrence. Completed on September 15, 1998.

Recommendation 13. The FAA should extend the charter of the Runway Incursion Subcommittee. Action plan reference: 1Eb.

The Runway Incursion Subcommittee officially disbanded on April 12, 1999.

Response to Committee Guidance on FAA's Planned Fiscal Year 2001-2005 Research and Development Investments (letter dated November 18, 1998)

Each year in September, the Committee provides recommendations on how FAA should invest its R,E&D funds. The Committee provided guidance for FAA's planned fiscal year 2001-2005 research and development investments in a letter to the Administrator dated November 18, 1998. The recommendations and FAA's responses are provided below.

a. **Recommendation:** FAA should develop a plan for ATM modernization expressed in terms of quantitative goals for evolving operational capabilities and user benefits. The Concept of Operations and the NAS Architecture should be tied to this ATM Modernization Plan. Furthermore, the R&D plans should in turn be tied to the Concept of Operations and NAS Architecture and should explain what R&D needs to be done, and by when, in order to support these plans.

   Response: FAA agrees and is in the process of quantifying benefits for the NAS Architecture. Benefits are first being identified qualitatively for the capability provided in terms of flexibility, predictability, delay reduction, etc. Quantitative evaluations of benefits are part of Concept Validation, which has just begun in fiscal year (FY) 1999.

b. **Recommendation:** FAA's Airport Pavement Program is an important program that is providing critical information for establishing pavement design standards that will affect every nation that is a member of the International Civil Aviation Organization (ICAO). Increasing pavement life by as little as 10 percent as a result of pavement research would yield cost savings of $200 million per year. The Committee recommends that FAA continue to fund this important effort.

   Response: FAA concurs with this recommendation and will continue to pursue this program. However, at the current R&D budget levels, funding may be less than desired for the most effective program.

c. **Recommendation:** The Committee recommends that FAA continue to concentrate R&D efforts in FY 2001, and beyond, on the issues arising from aging aircraft fleets. New technology aircraft will exhibit different problems as they age. In conjunction with advancing inspection and maintenance technologies, FAA must continue to develop the safety database and related analyses techniques that will generate leading indicators of potential safety problems. The feedback from this analysis must be incorporated into operating regulations and certification standards in a timely manner so as to prevent new accident modes.

   Response: FAA concurs with this recommendation and will continue to pursue this program and expand it to include nonstructural systems.

d. **Recommendation:** The Committee recommends that programs dedicated to prevention and containment of fire, both on board and post crash, continue to receive the highest priority for funding. As recent events demonstrate, ignition sources will be present on aircraft in their electrical systems, in luggage, or in cargo containers. Every effort must continue toward the elimination of ignition sources. The containment of a fire before an aircraft is lost either on the ground or in the air, must continue as a top priority in FY 2001 and beyond. The Committee feels that NASA could and should invest more money in long-term fire research.

   Response: FAA agrees that fire is an important risk factor and will continue to support a strong R&D program. Important criteria and test standards for insulation flame promulgator and burn through are about to be com-

pleted. FAA will ask NASA to conduct research in fire safety. However, FAA disagrees that fire safety should receive higher priority than other safety issues that place passengers at greater risk. These include crew errors and weather.

e. **Recommendation:** Current FAA environmental research is a limited effort which, if not strengthened adequately within the agency, will eventually restrict the growth of the aviation system. An increased level of focused strategic research is needed to (1) advance abatement technology, (2) identify appropriate environmental standards, and (3) develop environmental assessment computer models. The Committee recommends that FAA give priority to increasing environmental assessment capability in the areas of engine emission certification as well as model development for mandated requirements.

Response: FAA plans to sustain the environment and energy program with only modest growth. Currently, FAA is in the process of increasing the environment and energy program's R&D staffing with operations researchers for the purpose of model development. To increase funding significantly would take away from higher priority areas of safety, NAS efficiency, and/or security.

f. **Recommendation:** The Committee recommends that FAA reconsider diverting 20 percent of its planned investments in aviation security to high priority requirements for air traffic services research. We do not feel that the money is being misused, but that it would be more in the National interest to support NAS modernization and the transition to free flight. In the past, FAA has disagreed with this recommendation citing the results of the Gore Commission and the Nation's concern over security. The Committee recommends that FAA reconsider it at this time.

Response: Aviation security R&D remains a high interest area of Congress. We do not believe Congress would support shifting funds from security to other R&D programs. We believe the multidimensional threat environment requires a strong R&D program that supports future security equipment deployment and training.

Committee Recommendations from the Air Traffic Services Subcommittee (dated March 5, 1999)

The Air Traffic Services Subcommittee is one of the six standing subcommittees established in January 1997 to provide recommendations to the FAA on its proposed R,E&D investment portfolio and to conduct annual reviews of FAA's research and development program.

The Subcommittee Report was approved by the Committee on January 21, 1999 and provided by letter to the Administrator on March 5, 1999. The following response was presented to the Committee by letter dated July 1, 1999.

GENERAL RECOMMENDATIONS:

a. **Recommendation**: FAA lacks any real long-range air traffic services research and development programs.

Response: There are some efforts devoted to long-range research and development in the air traffic services area. These include human factors R&D, which addresses long-term issues in air traffic and airway facilities, and aviation weather R&D. Mid- and long-range ATC automation decision support tools R&D are part of a joint FAA/NASA ATM R&D program, which includes substantial efforts by NASA, FAA, CAASD, MIT/LL, and Volpe Center. However, we agree that the ATS R&D program has not been presented to the REDAC in a cohesive manner and could be improved.

b **Recommendation:** The transfer of funds from R&D to F&E and operations further weakens and confuses the R&D program.

Response: We agree it may cause confusion, particularly to those outside FAA. FAA is trying to minimize confusion by coordinating the R,E&D and F&E Advanced Technology and Prototyping planning processes to produce a balanced R&D program. The ATS Subcommittee will continue to have overview of both elements.

c **Recommendation:** There is virtually no focus on the major challenge of system and airport capacity, of which capacity-increasing technologies and procedures are a part.

Response: Although we may not be doing all we should, FAA is pursuing several capacity-increasing programs. These include the following:

- Technologies to increase capacity in the terminal airspace and airport surface include TMA, FAST, CDM, SMA, and other advanced tools under development.
- Capacity increasing R&D is included under the Ops Concept Validation Program and the System Capacity Program.

We welcome specific recommendations for additional high payoff R&D in systems and airport capacity.

SPECIFIC RECOMMENDATIONS:

1. **Recommendation:** Based on the priority being given to near-term system improvements, we note again that the current efforts are seemingly all directed at implementing things on which the real R&D was done years ago. These things need to be implemented rapidly and we support them enthusiastically. However, there appears to be little, if any, real R&D efforts associated with the integration of the near-term improvements to a more capable system for the future. There is acknowledgment within the FAA that the absolutely crucial work for the future is not being addressed. Without a vigorous R&D program, nothing will be ready to be implemented after Free Flight Phase 1. This lack of early planning could easily lead to a long gap in implementation of completed research. Our NASA friends have pointed out that NASA's research stops short of fieldable sys-

out that NASA's research stops short of fieldable systems and requires important FAA R&D to complete the efforts if the NASA research is to be successful. Others outside the United States are doing meaningful R&D and the U.S. will inevitably lose its eminent role.

Response: FAA concurs with this comment. Products resulting from a vigorous R&D program from 1991 to 1995 allowed FAA to pursue Free Flight Phase 1 (FFP1). However, over the last 4 years, FAA's ATM R&D budget has decreased substantially. NASA and CAASD continue developing advanced tools, but there is little FAA investment to be prepared for implementation beyond FFP1 because of severe budget problems in the Facilities and Equipment (F&E) budget.

2. **Recommendation:** The R&D situation has been further aggravated by the shift of money to F&E and Operations. Congress moved most of the Air Traffic Management programs and all of the Airports technology programs to the Facilities and Equipment (F&E) budget, reflecting the emphasis on the near-term at the expense of the longer-term. With the R&D funding and responsibilities for implementation separated into so many different pots, the R&D management, focus and effort have been seriously compromised. The new Architecture and the new Operations Concept, on which ARA and ATS have been working hard and effectively, are of limited value if they don't clearly show where we need to go – regardless of funding. However, without adequate funding, solutions will neither be achieved promptly or easily. The FAA should not indulge in the pretense that system modernization can be carried out with the present funding. Ms. Garvey, the FAA must find a way to convince Congress that the R&D budget must be increased. This budget issue requires exceptional action.

Response: FAA shares your concerns and agrees with the need for an increased R&D budget. Unfortunately, part of the price of balancing the United States budget is reduced spending. Right now, FAA R&D cannot compete with the other pressing priorities of our constrained budget.

3. **Recommendation:** We were briefed on the development and active pursuit of a new "Architecture" tool (which is an overall planning and scheduling tool depicting the steps to NAS modernization) being developed by FAA with its TRW contractor. It is potentially a very powerful tool, and we strongly encourage its wide internal and external use. Further work is required to evolve to provide the service evolution, as well as work to define the metrics of resultant benefits. It may be tempting to some to downplay or hide this powerful tool, because it will show starkly the consequences of inadequate funding, inadequate organization and inadequate system engineering, but it deserves your strong support.

Response: FAA notes the Committee's concern, but we are promoting its use, not hiding it. FAA plans to provide the tool to the desktop of all FAA executives as a decision support system.

4. **Recommendation:** Several of us have the impression that the close melding of the ARA Architecture and the ATS Operations Concept, which has been a major and highly welcome FAA accomplishment, is perhaps unraveling a bit. There is great value and importance of them staying close and fully tracking in unison, just as it is important that the new "Architecture" tool remain in lock step with these activities.

Response: We believe this is a misperception. The Architecture and Ops Concept are closely coupled. The Architecture Tool database is continuously updated to reflect

changes in budget or the Joint Government Industry Concept and FAA 2005 Concept.

5. **Recommendation:** We had a good briefing on the evolution of Flight 2000 (intended as a real life "beta test" of some of the new technologies) to Safe Flight 21. While this redirection is brand new, it is highly promising and we think it deserves strong support. While FAA is using RTCA as its advisory body on operational matters of Safe Flight 21, we stand ready to help on the R&D aspects of it.

   Response: FAA appreciates the Committee's support and its offer of assistance.

6. **Recommendation:** The lack of adequate and enough technical competence in FAA remains a critical matter, one which can not be resolved by hiring more support contractors and external body shops – it requires a critical mass of good people inside the FAA. Additional good program and technical managers, system and software engineers are needed.

   Response: FAA agrees. We are in the process of hiring several highly experienced Chief Systems Engineers and a few program technical managers. With a new staffing approach, we have more flexibility to hire personnel based on requirements and available budget; however, because of tight budgets, FAA may not be able to fill all of its staffing requirements.

7. **Recommendation:** FAA and NASA are trying, at the top level, to work together a bit more closely than before. However, the union is not yet nearly close enough, especially since NASA has a substantial part of the available R&D funds. We know about, and support, the efforts of Steve Zaidman and Sam Armstrong to bring the agencies together. As noted above, our NASA friends have pointed out that NASA's research stops short of fieldable systems, and requires an important FAA R&D effort. It will need unflagging attention from the highest levels in FAA – both ARA and ATS – if the money and efforts are to result in useful and timely products.

   Response: FAA agrees with the Committee's observations and is working to increase FAA's involvement with NASA R&D. The new FAA/NASA Executive Committee will facilitate a closer partnership, coordinated planning, and executive level monitoring.

Committee's Recommendations on Fiscal Year 2001-2005 R,E&D Investment Portfolio (dated June 11, 1999 – response pending)

At the April 21, 1999, Committee meeting, the Committee reviewed FAA's planned FY 2001-2005 R,E&D Investment Portfolio and provided recommendations to FAA in a letter dated June 11, 1999 from Committee Chairman Mr. Robert Doll to Administrator Jane Garvey.

Recommendations:

We are now working with the appropriate people in NASA to assure the maximum coordination of our respective advisory committee efforts and RE&D programs we are charged to oversee. A coordinating committee composed of members of the REDAC and NASA's ASTAC has been formed for the purpose of coordinating the goals of the agencies. An initial meeting of the new committee will be held June 22 through June 24.

All of the concerns that have been underlying the REDAC's efforts for the past few years are still prevalent and, in fact, growing in many areas. Of particular concern is the continuing lack of funds appropriated to the FAA and NASA to support research for aviation and the shift of significant RE&D budget allocations to F&E accounts.

Not a meeting goes by without a discussion of the serious consequences of the continued under funding of the RE&D aviation budget. The comparative level of RE&D expenditures within the European Union continues as a topic of interest to the REDAC. The U.S. aviation industry produces hundreds of billions of gross revenue dollars annually and accounts for a large proportion of our foreign trade revenues. The percentage of the gross revenues that the U.S. aviation/aerospace industry spends on RE&D is scandalously small. The responsibility lies with both the government and the private sector.

If we do not pay attention to developing the systems, facilities and equipment needed to handle the growth that our economy demands of the air transportation system, the growth of our economy will be adversely affected. This is a very simple equation.

I understand from industry sources that a major new study of European aviation related expenditures, including RE&D expenditures, is about to be released. I believe that this report will show that the US continues to be dramatically outspent in absolute terms by the EU in all areas of aviation RE&D.

We face the very real prospect of losing our lead in air traffic management systems and standards and the related hardware that we have traditionally supplied to the global aviation community. The potential impact to our economy of the loss of industry leadership is difficult to estimate.

A visit by a high level FAA team will take place with European leaders this month. We understand that US interests are entitled by treaty to share in the results of European RE&D efforts. We need to take advantage of this right to access the RE&D work in Europe. We strongly support this meeting.

The idea that the portion of RE&D expenditures funding needed for facilities and equipment is not related to RE&D but to project implementation is a bad idea. Equipment and facilities acquisitions are an integral part of the RE&D process. To remove these expenditures from the RE&D budget incurs a high risk of the money disappearing from RE&D availability over the longer term. It is imperative that any RE&D funds that have been moved to the F&E Budget be effectively "fenced" for RE&D like activities.

In our eyes, the acquisition of facilities and equipment for RE&D outside of the purview of RE&D personnel is fraught with danger. We fear that the research requirements for specific

features of that equipment could be lost on F&E acquisition personnel.

This is a major concern in the Airport Technology RE&D budget where all of the dollars were moved to F&E. What may not be apparent to the decision-makers is that the Pavement Test Facility is completed. There will be very little spending required on F&E in the future for Airport Technology RE&D. Therefore there is no rationale for having Airport Technology funding in the F&E budget.

The REDAC supports the FY 2001 RE&D budget as constructed by the roll-up of the individual RPD requirements. We believe that a strong effort to meet this funding level is required of the FAA before the GAO and Congress. We hope that the idea of Flagship Initiatives is pursued to provide a significant boost to FY 2001 funding

The high-level budget requirements for FY 2001 were presented to us in our April meeting. The FY 2001 requirements and the comparable previous year request and authorizations are:

Category	FY 1999 Appropriation	FY 2000 President's Budget	FY 2001 RPD Requirements
Aircraft Safety	$ 34.9	$ 39.6	$ 60.0
Aviation Security	$ 51.7	$ 53.2	$ 66.3
Environ & Energy	$ 2.9	$ 3.5	$ 7.4
Human Factors	$ 25.1	$ 26.2	$ 29.7
R&D Management	$ 2.2	$ 2.7	$ 2.7
ATM	$ 90.9	$ 94.0	$ 132.2
Safe Flight 21*	$ 16.0	$ 16.0	$ 30.0
Airport Technology**	$ 5.0	$ 7.2	$ 10.0
CAASD ATM R&D***	$ 31.8	$ 35.8	$ 37.4
Total	$ 260.5	$ 278.2	$ 375.7

- *** FY 1999 Safe Flight Funds are in the F&E Account**
- **** All Funding is in the F&E Account**
- ***** Funds are provided from the RE&D and F&E Accounts**

Congress has essentially mandated the level of the Aviation Security expenditure. The explicit Human Factors portion of the entire budget is significant and includes monies dedicated to Aircraft Safety and ATM RE&D projects. We would like to see more money spent in Human Factors but the practicalities of anticipated funding and mandates do not allow reallocation of money from other RPDs into the explicit Human factors efforts. We believe that industry must step up to supporting efforts such as Human Factors and Aircraft Safety to bring themselves more in line with the benefits they derive from those efforts.

The severe budget cuts proposed for NASA are truly alarming to the REDAC. The prevailing view in the industry is that NASA may need to be renamed NSA, dropping any reference to "Aeronautics" in their name if the present budget cuts are sustained. NASA's leaders have stated that they will eliminate efforts related to aeronautics in order to maintain their space program expenditures.

The REDAC believes that progress on aircraft engine emissions and noise-related research will be severely impacted as NASA is forced to wind down current research efforts. The cessation of funding for noise and emission research is not in

the public interest. The FAA will be hampered in its future efforts to effectively certify new systems and to produce effective regulation for the air transport system. Discontinuities in basic research can't be recovered. The simple fact is that, even if money could be transferred from the NASA research budget to the FAA RE&D budget, the money would not be effectively spent as the FAA is not equipped or staffed to accomplish basic RE&D.

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APPENDIX B

LISTS OF ACRONYMS ALPHABETICAL LISTING OF NATIONAL AVIATION RESEARCH PLAN BUDGET LINE ITEMS

Budget Program	Item Number	Page
Operations Concept Validation	1F01	2-22
Propulsion and Fuel Systems	A06c	2-81
Runway Incursion Reduction	1F01	2-6
Safe Flight 21		2-18
Separation Standards	1F01	2-50
Software Engineering R&D	1F01	2-26
Surveillance	1F01	2-40
System Capacity, Planning and Improvements	1F01	2-10
System Planning and Resource Management	A01a	2-160
Weather Program	A04a	2-54
William J. Hughes Technical Center Laboratory Facility	A01b	2-163

APPENDIX C

NUMERICAL LISTING OF NATIONAL AVIATION RESEARCH PLAN

Project Number	Budget Program	Budget Item
011-130	System Planning and Resource Management	A01a
011-140	William J. Hughes Technical Center Laboratory Facility	A01b
011-160	Center for Advanced Aviation System Development (CAASD)	A01c
041-110	Weather Program	A04a
060-110	Aviation Safety Risk Analysis	A06g
061-110	Fire Research and Safety	A06a
062-110/111	Advanced Materials/Structural Safety	A06b
063-110	Propulsion and Fuel Systems	A06c
064-110/111	Flight Safety/Atmospheric Hazards Research	A06d
065-110	Aging Aircraft	A06e
066-110	Aircraft Catastrophic Failure Prevention Research	A06f
071-110	Explosives and Weapons Detection	A07a
073-110	Airport Security Technology Integration	A07b
075-110	Aircraft Hardening	A07d
076-110	Aviation Security Human Factors	A07c
081-110	Flight-Deck/Maintenance/System Integration Human Factors	A08a
082-110	Air Traffic Control/Airway Facilities Human Factors	A08b
086-110	Aeromedical Research	A08c
091-110/111/113	Environment and Energy	A09a
1127085500	Navigation	1F01
26600855002	System Capacity, Planning and Improvements	1F01
2661085500	Separation Standards	1F01
2680085599	Communications	1F01

Project Number	Budget Program	Budget Item
4554085599	Runway Incursion Reduction	1F01
6710085500	Surveillance	1F01
9720085500	Airspace Management Lab	1F01
9861085599	Operations Concept Validation	1F01
9875085500	Software Engineering R&D	1F01
9882085599	General Aviation and Vertical Flight Technology Program	1F01
TBD	ATC/ATM Decision Support	1F01
TBD	Safe Flight 21	
TBD	Information System Security	A01d
TBD	Airport Technologies	

APPENDIX D

LISTS OF ACRONYMS

The following high-frequency or generally well known acronyms often appear in the text of this plan without statement of their full equivalent.

ATC	Air Traffic Control
ATM	Air Traffic Management
ATS	Air Traffic Services
DOD	Department of Defense
DOT	Department of Transportation
EPA	Environmental Protection Agency
F&E	Facilities and Equipment
FAA	Federal Aviation Administrator
GAO	General Accounting Office
NAS	National Airspace
NASA	National Aeronautics and Space Administration
OMB	Office of Management and Budget
R&D	Research and Development
R,E&D	Research, Engineering and Development
REDAC	Research, Engineering and Development Advisory Committee
TRACON	Terminal Radar Approach Control

The following acronyms will generally appear with their full equivalent stated at its first occurrence in each major section of this plan or each program description.

A

AAAE	American Association of Airport Executives
AANC	Aging Aircraft Nondestructive Inspection Validation Center

AC	Advisory Circular
ACARS	Airborne Collision Avoidance Radar System
ACAS	Airborne Collision Avoidance System
ACE	Aviation Capacity Enhancement
ACI-NA	Airports Council International – North America
ACSEP	Aircraft Certification Systems Evaluation Program
ADL	Aeronautical Data Link
ADS	Automatic Dependent Surveillance
ADS-B	Automatic Dependent Surveillance—Broadcast
AEAP	Aviation Effects on the Atmosphere Project
AED	Automatic External Defribilator
AGATE	Advanced General Aviation Transport Experiment
AGFS	Aviation Gridded Forecast System
AIA	Aerospace Industries Association
AIAA	American Institute of Aeronautics and Astronautics
AIP	Airport Improvement Program
ALEAN	Airport Law Enforcement Agency Network
ALPA	Airline Pilots Association
AMASS	Airport Movement Area Safety System
AMCP	Aeronautical Telecommunications Network Panel
AOC	Airline Operational Control
AOPA	Aircraft Owners and Pilots Association
APARMO	Asian/Pacific Approvals Registry and Monitoring Organization
APB	Acquisition Program Baseline
APEC	Asia Pacific Economic Cooperative
API	Adaptation Process Improvement
APMS	Automated Performance Measurement System
AQP	Advanced Qualification Program

ARAC	Aviation Regulatory Advisory Committee
ARTCC	Air Route Traffic Control Center
ASAC	Aviation Security Advisory Committee
ASDE	Airport Surface Detection Equipment
ASDI	Aircraft Situational Display for Industry
ASMM	Aviation Safety Risk Analysis
ASRA	NASA Aviation System Data Monitoring and Modeling
AST	Advanced Subsonic Technology
ASTI	Airport Security Technology Integration
ATA	Air Transport Association
ATC	Air Traffic Control
ATCA	Air Traffic Control Association
ATCS	Air Traffic Control Specialist
ATIS	Automated Terminal Information Service
ATM	Air Traffic Management
ATS	Air Traffic Services
ATSOIT	Air Traffic Satellite Operational Implementation Team
ATSP	Air Traffic Service Plan
AWT	Area Work Team
B	
BITE	Built-In Test Equipment
C	
CAA	(British) Civil Aviation Administration
CAASD	Center for Advanced Aviation System Development
CAEP	Committee on Aviation Environmental Protection
CAMI	Civil Aeromedical Institute
CAPS	Computer Assisted Passenger Screening
CASR	Center for Aviation Systems Reliability

CAST	Certification Authorities Software Team
CBT	Computer-Based Training
CDM	Collaborative Decision Making
CDTI	Cockpit Display of Traffic Information
CERAP	Center Radar Approach Control
CFIT	Controlled Flight into Terrain
CIS	Cockpit Information System
CNS	Communication, Navigation, and Surveillance
COCOTS	Constructive COTS
COE	Center of Excellence
COTS	Commercial-off-the-Shelf
CPBVE	Crew Protective Breathing and Vision Equipment
CPDLC	Controller Pilot Data Link Communications
CRC	Coordinating Research Council
CRDA	Cooperative Research and Development Agreement
CRDA	Converging Runway Display Aid
CRM	Crew Resource Management
CTAS	Center TRACON Automation System
D	
DARWIN	Design Assessment of Reliability with Inspection
D-ATIS	Digital-Automated Terminal Information Service
DFDR	Digital Flight Data Recorder
DOE	Department of Energy
DSR	Display System Replacement
DSS	Decision Support System
E	
EAA	Experimental Aircraft Association
EARTS	Enroute Automated Radar Tracking System

EDD	Explosives Detection Device
EDM	Expert Decision Making
EDS	Explosives Detection System
EEHWC	Electromagnetic Effects Harmonization Working Group
EGNOS	European Geostationary Navigation Overlay Service
EMS	Emergency Medical Service
ETC	Engine Titanium Consortium
F	
FANG	FMS-ATM Next Generation
FAR	Federal Aviation Regulation
FAST	Final Approach Spacing Tool
FEM	Finite Element Model
FICAN	Federal Interagency Committee on Aviation Noise
FIS	Flight Information Service
FL	Flight Level
FMS	Flight Management System
FQT	Formal Qualification Testing
FSM	Flight Schedule Monitor
FTE	Full Time Equivalent
FTHWG	Flight Test Harmonization Working Group
FY	Fiscal Year
G	
GA	General Aviation
GAMA	General Aviation Manufacturers Association
GDP	Ground Delay Program
GICB	Ground Initiated Comm B
GNSS	Global Navigation Satellite System
GPRA	Government Performance and Results Act

GPS	Global Positioning System
GWS	Graphic Weather Service
H	
HAI	Helicopter Association International
HFACS	Human Factors Analysis and Classification System
HIC	Head Injury Criteria
HIRF	High Intensity Radiated Field
HSI	Human Systems Integration
HUMS	Health/Usage Monitoring System
I	
IAIPT	Interagency ATM Integrated Product Team
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
ID	Intrusion Detection
IDACS	Intelligent Damage Adaptive Control System
IDM	Integrated Design and Manufacturing
IEEE	Institute of Electrical and Electronics Engineers
IFR	Instrument Flight Rules
IGEB	Interagency GPS Executive Board
IMT	Integrity Monitoring Test Bed
IPHWG	Ice Protection Harmonization Working Group
IPT	Integrated Product Team
IWG	Interoperability Working Group
J	
JAA	Joint Aviation Authorities
JRC	Joint Resource Council
JSAT	Joint Safety Awareness Team
L	

LAAS	Local Area Augmentation System
LTP	LAAS Test Prototype
LVLASO	Low-Visibility Landing and Surface operations
M	
MANPADS	Man Portable Air Defense Systems
MASPS	Minimum Aviation System Performance Standards
MMIR	Maintenance Malfunction Information Reporting
MOA	Memorandum of Agreement
MOPS	Minimum Operational Performance Standards
MOU	Memorandum of Understanding
MRM	Maintenance Resource Management
N	
NAPTF	National Airport Pavement Test Facility
NATCA	National Air Traffic Controllers Association
NAWCAD	Naval Air Warfare Center Aircraft Division
NCARC	National Civil Aviation Review Commission
NDI	Non-Developmental Item
NEXRAD	Next Generation Weather Radar
NHTSA	National Highway Traffic Safety Administration
NICE	North Atlantic Implementation Management Group Cost Effectiveness
NIOSH	National Institute for Occupational Safety and Health
NIST	National Institute of Standards and Technology
NLA	New Large Aircraft
NOAA	National Oceanic and Atmospheric Administration
NOTAM	Notice to Airmen
NPRM	Notice of Proposed Rulemaking
NQR	

NRS	National Resource Specialist
NSTB	National Satellite Test Bed
NTSB	National Transportation Safety Board
NWS	National Weather Service
P	
P3I	Pre-Planned Product Improvement
PBFM	Passenger Baggage Flow Model
PDC	Pre-Departure Clearance
PIP	Program Implementation Plan
PIREP	Pilot Report
PIRG	Planning and Implementation Regional Group
PPBM	Positive Passenger Baggage Matching
PPIHWG	Powerplant Installation Harmonization Working Group
R	
R&D	Research and Development
R,E&D	Research, Engineering and Development
RAA	Regional Aircarrier Association
RF	Radio Frequency
RGCSP	Review of the General Concept of Separation Panel
RIAT	Runway Incursion Action Team
RIRP	Runway Incursion Reduction Program
RITA	Rotorcraft Industry Technology Association
RNP	Required Navigation Performance
RVSM	Reduced Vertical Separation Minimum
S	
SAE	Society of Automotive Engineers
SAMA	Small Aircraft Manufacturers Association
SARPS	Standards and Recommended Practices

SATB	South American Test Bed
SATORI	Systematic Air Traffic Operations Research Initiative
SBAS	Satellite Based Augmentation System
SBIR	Small Business Innovative Research
SCAEP	Space Charged Aerosol Electrostatic Precipitator
SDTF	Surface Development and Testing Facility
SEIPT	Security Equipment Integrated Product Team
SERC	Software Engineering Resource Center
SFP	Surveilliance Fusion Platform
SICAS	Secondary Improvements and Collision Avoidance System
SITA	Societe Internationalale De Telecommunications Aeronautiques
SLD	Supercooled large Droplet
SMA	Surface Movement Advisor
SMPC	Specialty Metals Processing Consortium
SNI	Simultaneous Non-Interfering
SOIT	Satellite Operational Implementation Team
SPAS	Safety Performance Analysis System
SPEARS	Screener Proficiency Evaluation and Reporting System
SPIE	Society for Optical Engineering
SSAC	Streamlining Software Aspects of Certification
STARS	Standard Terminal Automation Replacement System
SUA	Special Use Airspace
SUPCOM	Support Command
SVM	Service Volume Model
T	
TAP	Terminal Area Productivity
TATP	Triacetone Triperoxide
TC	Transport Committee

TCA	Transport Canada Aviation
TCAS	Traffic Alert and Collision Avoidance System
TDLS	Tower Data Link System
TERPS	Terminal Instrument Procedures
TFM	Traffic Flow Management
TIP	Threat Image Projection
TIS	Traffic Information Service
TMA	Traffic Management Advisor
TMS	Traffic Management System
TOGAA	Technical Oversight Group On Aging Aircraft
TWIP	Terminal Weather Information for Pilots
U	
URET	User Request Evaluation Tool
USAF	U.S. Air Force
V	
VHF	Very High Frequency
VNTSC	Volpe National Transportation Systems Center
W	
WAAS	Wide Area Augmentation System
WATRS	West Atlantic Route System Separation Standards
WFD	Widespread Fatigue Damage
WJHTC	William J. Hughes Technical Center
WSDDM	Weather Support to Deicing Decision Making
WVSS	Water Vapor Sensing System